Risk-adjusted performance attribution and portfolio optimisation under tracking-error constraints for SIAS Canadian Equity Fund

By

Meadow Wu
BA (hon) Finance Accounting and Management, University of Nottingham, 2010

and
Christine Jakshoj
BSc Business Administration and Economics, Copenhagen Business School, 2009

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Approval

Name: **Meadow Wu**

Degree: **Master of Financial Risk Management**

Name: **Christine Jakshoj**

Degree: **Master of Financial Risk Management**

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Supervisory Committee:

Dr. Andrey Pavlov
Senior Supervisor

Dr. Derek Yee
Supervisor

Abstract

This thesis is inspired by the article “Risk-adjusted performance attribution and portfolio optimizations under tracking error-constraints” by Bertrand (2008) together with some hand-on experience gained though managing a portfolio worth over $10 million CAD of the Simon Fraser University endowment Fund for one year. This paper explores the theories of attributing portfolio risk, in the form of tracking-error volatility into asset allocation attributes and stock selection effects in accordance with the arithmetic performance attribution method. Then it applies the same attribution method in calculating the risk adjusted return (information ratio) for a normal portfolio and compare this to a TEV optimal portfolio. We apply the information ratio and tracking-error variance model to the SIAS Canadian Equity portfolio with approximately $4 million CAD in value to test the following:

If the SIAS Canadian Equity portfolio sector weights remain the same, what is the expected information ratio? And will this be improved by optimizing the sector weights according to the tracking-error variance frontier?

We will then test the robustness of our findings by changing the time period and perform a sensitivity analysis on the estimated expected returns. We will also compare the results with those derived from the mean-variance optimization, by applying mean-variance optimal weights and recalculate the expected information ratio. The findings are as follows: The TEV optimized weights does improve the expected information ratio for a portfolio. This finding is further verified since it gives the same result with different time periods. The sensitivity analysis gives us an interval that the optimized sector weights will be within that interval with 95% probability. Moreover, the comparison to the mean-variance optimized portfolio shows that the tracking-error variance optimization gives less extreme results and is easier to implement, while maintaining a positive expected excess return compared to the benchmark.

Contents

1.0 Introduction

Risk has always been treated as an important component for portfolio managers when making asset allocation and stock selection decisions (Bertrand 2005). Therefore, how to incorporate risk attribution in performance measurement and trying to come up with a risk-adjusted return has been a hot topic in recent years (Menchero 2007, Bertrand 2008 and Mina 2003). This paper adopts the arithmetic performance attribution first introduced by Brinson et al (1986) which attributes the performance to either asset allocation effect, meaning the strategic weighing of different asset classes or stock selection effect, meaning the performance of the stocks picked by portfolio managers within each sector. This paper uses tracking-error variance and its square root (tracking error) as the main risk parameter and divides it into that which can be attributed to asset allocation decisions and stock selection decisions respectively.

We want to show that using the tracking-error variance as a risk factor is useful for all portfolio managers, even if their client focuses only on the excess return compared to a given benchmark.

Our hypothesis is that using tracking-error variance optimization (minimize the tracking-error with respect to a given target excess return) to find sector weights is the optimal solution for all portfolio managers getting evaluated relative to a benchmark.

We will discuss using the information ratio as the risk adjusted return, and how we can separate the two traditional attribution effects, asset allocation and stock selection, for both tracking-error variance efficient portfolios and portfolios without consideration of tracking-error variance or mean-variance efficiencies. Our hypothesis is that the expected risk adjusted return will increase when adapting tracking-error variance optimal weights.

We will test the model and our hypothesis on the SIAS Canadian Equity portfolio by calculating the expected return and information ratio with the current weights in each sector. Then we will optimize the weights under tracking-error variance constraint and re-calculate the numbers. We will further try to verify our findings by repeating the exercise on a different time period. We will also complete a sensitivity analysis to provide a confidence interval for the optimal sector weights. Lastly, we will compare the SIAS Canadian Equity portfolio with the tracking-error variance optimal weights with the portfolio adapting mean-variance optimal weights to see how the optimal sector weights differs between the traditionally used optimization method(mean-variance) and the proposed tracking-error variance optimization. We will also see how the information ratio will be affected.

This paper will assist performance analysts as well as portfolio managers in the following ways: Firstly, we test the theory developed by Bertrand on SIAS Canadian Equity portfolio, which is the first time the portfolio-optimization theory under tracking error constraints is applied to an actual fund.

Secondly, we modified the theory by applying it to a single asset group instead of a whole fund with various assets classes. Therefore, instead of breaking down the excess return to asset classes, we break it down to sector levels, which offer more details on how to implement this optimization method in depth.

Thirdly, even for those portfolio managers whose performance is not evaluated as a risk-adjusted return but rather the relative return compared to a benchmark, taking into consideration of tracking-error variance is crucial as it offers more insight of how an investment decision will affect the portfolio relative to the benchmark. It thus provides a more comprehensive picture to the portfolio managers as how much relative risk they are adding to the portfolio while making an investment decision.

2.0 Denotation:

U: the asset universe

i: the number of assets within the universe. i= 1, … , m=#(U)

{U1, … , Un}: a subset of n assets in set U, where i=1,…, n≤m.

p: portfolio

b: benchmark, where b and p have the same amount of sectors, n

R_l: the return of sector l

$\bar{R}_l$: the expected return of sectors l

σ_{kl}: the covariance between the returns of sector k and sector l

Z_{pl}: the weight of sector l in the portfolio

Z_{bl}: the weight of sector l in the benchmark

w_{pi}: the weight of sector i in the portfolio, where $wpi = \Sigma l \in Uizpl$

w_{bi}: the weight of sector i in the benchmark, where $wbi = \Sigma l \in Uizbl$

R_{pi}: the return of sector i in the portfolio, where $R_{pi} = \Sigma l \in Ui w^{(i)}_{pl} R_l$

R_{bi}: the return of sector i in the benchmark, where $R_{bi} = \Sigma l \in Ui w^{(i)}_{bl} R_l$

3.0 Literature review

3.1 Performance Attribution

Most industry professionals have adopted the arithmetic performance attribution method when evaluating a portfolio's performance, which was first introduced in 1986 by Brinson et al (Bertrand, 2008 and Brinson et al, 1986, 1991). This paper adopts the original method that separates the relative performance attribution of the fund or portfolio into asset allocation and stock selection effects, which explains respectively whether the value added comes from the strategic weighting of each sector (asset allocation) or from the superior stock picking within each sector (stock selection). Note that in this paper, the interaction effect, which captures the excess return that is added to the selection effect and therefore not explained separately. Also, this paper does not distinguish the weights and returns based on either ex ante or ex post results.

The excess return of the portfolio over a certain period of time is calculated by deducting the benchmark return from the portfolio return, which can be broken down as the sum of the weighted portfolio return minus corresponding weighted benchmark return in each sector (Brinson et al, 1986 and Bertrand, 2008). Taking the expected value, we generate the following equation:

$$\alpha = \mathrm{R_p} - \mathrm{R_b} = \sum_{i=1}^{n}\left(\mathrm{w_{pi}R_{bi}} - \mathrm{w_{bi}R_{bi}}\right) = \sum_{l=1}^{m}\left(\mathrm{Z_{pl}} - \mathrm{Z_{bl}}\right)R_l$$

$$\bar{\alpha} = \bar{R}_p - \bar{R}_b = \sum_{i=1}^{n}\left(\mathrm{w_{pi}}\bar{R}_{pi} - \mathrm{w_{bi}}\bar{R}_{bi}\right) = \sum_{l=1}^{m}(Z_{pl} - Z_{bl})\,\bar{R}_l \quad (1)$$

Decompose the excess return to the two attributes, asset allocation and stock selection we get asset allocation that can be written as

$$\overline{AA} = \sum_{i=1}^{n}(\mathrm{w_{pi}} - \mathrm{w_{bi}})(\bar{R}_{bi} - \bar{R}_b) \quad (2)$$

Breaking it down to sector level, the value added through asset allocation for each sector primarily comes from the difference in the weighting of each sector between portfolio and benchmark as well as the difference between the benchmark return of each sector and the expected benchmark return for the whole portfolio.

$$\overline{AA}i = (w_{pi}\text{-}w_{bi})\,(\bar{R}_{bi} - \bar{R}_b) \qquad (3)$$

Stock Selection can be expressed as

$$\overline{SS} = \sum_{i=1}^{n}\mathrm{w_{pi}}(\bar{R}_{pi} - \bar{R}_{bi}) \qquad (4)$$

On a sector level analysis, we get

$$\overline{SS}i = w_{pi}\,(\bar{R}_{pi} - \bar{R}_{bi}) \qquad (5)$$

3.2 Critics of Performance attribution:

The major criticism the arithmetic performance attribution method receives is that it leaves out the consideration of risks (Bertrand, 2008). Therefore, problems may arise when a decision which helps reduce contributed risk to the portfolio is penalized under the attribution method, or when the portfolio is outperforming, but only does so because the risks associated is higher than the benchmark (ibid.).

Roll (1992) made an argument that this dilemma can be solved by applying the performance attribution method to portfolios that are plotted on the tracking error-variance efficient frontier. This was overthrown by Bertrand (2005), who stated that without adopting a clear risk-adjusted return evaluation, some optimal decisions under return-risk trade off mechanisms can still be interpreted adversely.

3,3 Risk Attribution:

According to Litterman's (1996) portfolio risk management theory, tracking-error variance or tracking-error, should be adopted as the main risk measure because of the following reasons: Firstly, tracking-error variance evaluates the extra risks taken by a portfolio relative to its benchmark. Secondly, it can be decomposed in a way that reflects the risk-components resulting from either asset allocation or stock selection, and it is thus consistent with the arithmetic performance attribution method explained in the previous section. (Bertrand, 2008)

Tracking error can be written as below

$$T = \frac{T^2}{T} = \frac{(Zp-Zb)'V(Zp-Zb)}{\sqrt{(Zp-Zb)'V(Zp-Zb)}} = \frac{Cov(\alpha,\alpha)}{T} \quad (6)$$

Take the Equation 3, 5 into Equation 6, we get:

$$= \frac{1}{T}[Cov\left(\sum_{i=1}^{n}(\text{wpi} - \text{wbi})(R_{bi} - R_b), \alpha\right) + Cov\left(\sum_{i=1}^{n}\text{wpi}(R_{bi} - R_b), \alpha\right)$$

$$= \frac{1}{T}[Cov(AA, \alpha) + Cov(SS, \alpha)]$$

Given that $Cov(AAi, \alpha) = (\text{wpi} - \text{wbi})Cov(Rbi - Rb, Rp - Rb)$, the risk associated with asset allocation is reduced when:

a) W_{pi}-W_{bi} is negative while Covariance is positive. - The sector is over-weighted compared to benchmark while *"the excess return of sector i in the benchmark over the benchmark return, co-varies negatively with total portfolio excess return"*(Bertrand, 2008 p.78)

or

b) W_{pi}-W_{bi} is positive while the Covariance is negative. -The sector is underweighted compared to benchmark while *"the excess return of sector I in the benchmark and benchmark return, co-varies positively with total portfolio excess return"*(Bertrand, 2008 p.78)

Given that $Cov(SSi, \alpha) = wpiCov(Rpi - Rb, Rp - Rb)$, the risk associated with stock selection is reduced when *"The excess return of sector i in the portfolio relative to the benchmark, co-varies negatively with total portfolio excess return with respect to the benchmark"*(Bertrand, 2008 p.78)

To further develop the equation for tracking-error in accordance with the performance attributes – asset allocation and stock selection, we get the following

$$T = \sum_{i=1}^{n}[\sigma(AAi)\rho(AAi,\alpha) + \sigma(SSi)\rho(SSi,\alpha)] \quad (7)$$

$$=\sum_{i=1}^{n}[(\mathrm{w}_{\mathrm{pi}} - \mathrm{w}_{\mathrm{bi}})\sigma(R_{bi} - R_{b})\rho(AAi,\alpha) + \mathrm{w}_{\mathrm{pi}}\sigma(R_{pi} - R_{bi})\rho(SSi,\alpha)] \quad (8)$$

where,

$$\sigma(AAi) = \sigma((\mathrm{w}_{\mathrm{pi}} - \mathrm{w}_{\mathrm{bi}})(R_{bi} - R_{b}))$$

$$\sigma(SSi) = \sigma\left(\mathrm{w}_{\mathrm{pi}}(R_{pi} - R_{b})\right)$$

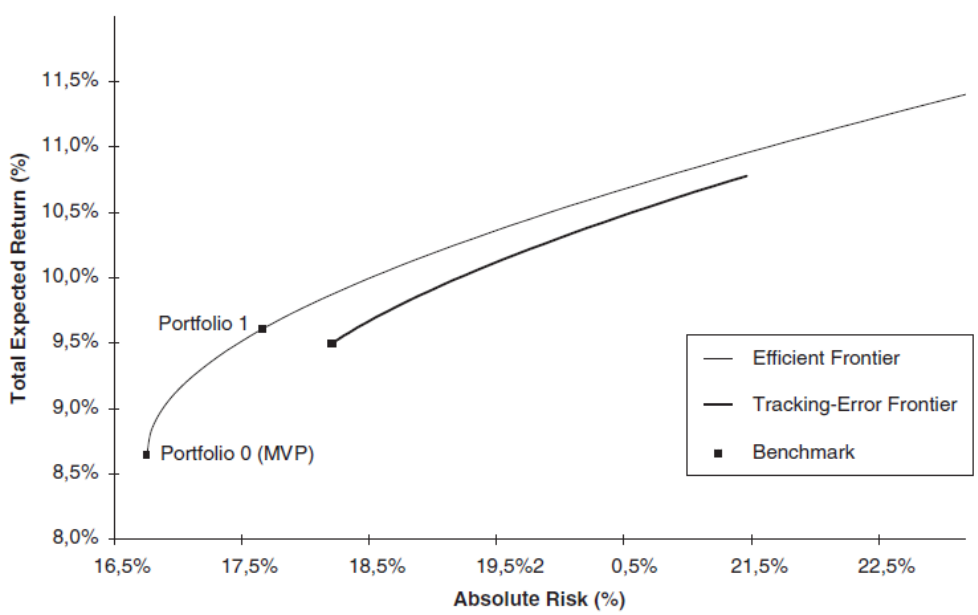
$$\frac{Cov(X_i,\alpha)}{T} = \frac{Cov(X_i,\alpha)}{\sigma(\alpha)} = \sigma(Xi)\rho(Xi,\alpha), \qquad (9)$$

$$X_i = \{AAi, SSi\}$$

3.4 Tracking-error Variance efficient portfolio – Roll (1992), Jorion(2003)

Tracking-error efficient portfolios refer to those portfolios that are plotted on the tracking-error efficient frontier. It is constantly used to when there is a constraint posed on the tracking error of the portfolio as opposed to the benchmark (Roll, 1992). Therefore, portfolio managers are expected to minimize the amount of relative risks for each level of excess return. Plotted on the same graph with total expected return and absolute risk as the y and x axis respectively, the tracking-error variance frontier is constantly to the right of the mean-variance efficient frontier, with benchmark portfolio on the former frontier and minimum-variance portfolio on the latter (Bertrand, 2008).

Figure 1 -The Mean-Variance Efficient Frontier compared to the TEV Efficient frontier (*Bertrand, 2008 p.86 Appendix*)



Imposing tracking-error constraint on portfolio management is introduced and widely adopted in the industry with the hope of bringing a more accurate frontier and better regulate the decision making (Jorion, 2003; Roll 1992). However, Jorion (2003) pointed out that this may also lead to inefficiency as portfolio managers will ignore total risk of the portfolio while concentrating on solely excess return and tracking error risk. Thus, there are concerns such as obtaining easy risk adjusted return by "leveraging up the benchmark" (Jorion, 2003).

3.5 Information Ratio -*Risk adjusted performance attribution*

As a widely adopted measure of risk adjusted return, the Information Ratio (IR) is calculated by dividing the excess return of a portfolio over its benchmark by its tracking error (Bertrand, 2005 and Menchero, 2007). Following the method we proposed in the previous sections, we can decompose the information ratio into two parts, one equivalent to asset allocation and one equivalent to stock selection. In general, there are two ways of doing that. One way as proposed by Bertrand (2005) applies to all portfolios plotted on the tracking-error variance efficient frontier and one as developed by Xiang (2006) and Menchero (2007) that can be applied without considering the efficiency of the portfolio.

Bertrand (2005) made the assumption that the benchmark against which the portfolio is evaluated is not mean-variance efficient, which was proved true in practice by Grinold (1992). Therefore, for all portfolios on the tracking-error variance efficient frontier, the standard deviation of the tracking-error should be considered an optimal risk attribution when decomposing the portfolio IR into allocation contribution and selection attribution, which is calculated as $\frac{\mathrm{cov}(\mathrm{AAi},\alpha)}{\mathrm{T}}$ and $\frac{\mathrm{Cov}(\mathrm{SSi},\alpha)}{\mathrm{T}}$ respectively. This is further justified that an asset allocation or stock selection decision, which results in negative excess return, will, in general, reduce the relative risk (Bertrand 2008). Therefore the decomposition of the information ratio of the tracking-error variance frontier portfolio into asset allocation contribution and stock selection contribution can be written as follows:

$$IR(AA_i) = \frac{(\mathrm{w_{pi}}-\mathrm{w_{bi}})(\overline{R_{bi}}-\overline{R_b})}{Cov(AA_i,\alpha)/T} = IR_p \qquad (10)$$

$$IR(SS_i) = \frac{\mathrm{w_{pi}}(\overline{R_{pi}}-\overline{R_{bi}})}{Cov(SS_i,\alpha)/T} = IR_p$$

Bertrand (2008) found that

"The information ratio of each component of the risk attribution decomposition is the same and is equal to the information ratio of the whole portfolio"

Which means that there exists a Pareto efficiency in the decomposition of information ratio for tracking-error variance frontier portfolios, as it achieves an equilibrium in that there does not exist a way of improving one without hurting the other (Bertrand, 2008).

A more general framework of decomposing the IR in accordance with the two attributes is proposed by Xiang (2006) and further discussed in Menchero (2007). This approach takes away the constraint of portfolios being on the tracking-error variance efficient frontier and mean-variance efficient frontier. It uses the tracking-error (as opposed to tracking-error variance) as the risk attribution factor, and thus the IR for the whole portfolio can be written as

$$IRp = \frac{\bar{R}_p - \bar{R}_b}{\sigma(\bar{R}_p - \bar{R}_b)} = \frac{\bar{\alpha}}{T} = \sum_{i=1}^{n}(\frac{\overline{AA}_i + \overline{SS}_i}{T}) = \sum_{i=1}^{n}\sum_{m=1}^{2}\frac{\bar{X}_{im}}{T}$$

Menchero (2007) further developed this equation by first including the factor $\frac{\mathrm{Cov}(X_{im},\sigma)}{T}$ (by multiplying it and dividing it at the same time) and then rearrange the equation into

$$IRp = \sum_{i=1}^{n}\sum_{m=1}^{2}(\frac{Cov(X_{im},\alpha)}{T^2} * \frac{\overline{X_{im}}}{Cov(X_{im},\alpha)/_T}) \qquad (11)$$

Take Equation 9 into Equation 11, we get

$$IRp = \sum_{i=1}^{n}\sum_{m=1}^{2}(\frac{\sigma(Xim)\rho(Xim,\alpha)}{T} IR(Xim)) \qquad (12)$$

Where, IR (X_{im}) $=(1/_{\rho(Xim,\alpha)})\ (\overline{X\iota m}/_{\sigma(Xim)})$

It can be seen that the IR is composed of two parts: The first part is the risk weight, which denotes the relative amount of risk decision "im" to the whole portfolio; the risk weights of each sector should therefore add up to one. The second part is IR (Xim), which denotes the IR decision "im" results. $\overline{X\iota m}/_{\sigma(Xim)}$ represents the absolute information ratio of decision "im" while the factor $1/_{\rho(Xim,\alpha)}$ adjusts the information within the context of the whole portfolio to cater the diversification effect the decision brings. Thus, Bertrand (2008) proposes that in order to evaluate how a decision influences the information ratio of the whole portfolio, we need to go into a detailed analysis of how the three components interact at different levels: Firstly, the absolute IR is considered. The sign of this component is dependent on that of $\overline{X\iota m}$. Secondly, the component information ratio, is analyzed. The sign of this component is dependent on those of $\overline{X\iota m}$ and ρ.

${}^{1}/_{\rho(Xim,\alpha)}$ determines the sign of the risk weight. Thirdly, the contributed information ratio in the context of the whole portfolio is examined. The sign of this component is dependent on that of $\overline{X\imath m}$. (Bertrand, 2008)

Bertrand (2008) introduced a table to illuminate the interaction of the three components:

Figure 2 – Table to explain decomposed IR (Bertrand, 2008 p.79)

	$\rho(X_{im}, S)>0$ $(RW_{im}>0)$	$\rho(X_{im}, S)<0$ $(RW_{im}<0)$
$\bar{X}_{im}>0$	$\bar{X}_{im}/\sigma(X_{im})>0$, $IR(X_{im})>0$, $\bar{X}_{im}/T>0$	$\bar{X}_{im}/\sigma(X_{im})>0$, $IR(X_{im})<0$, $\bar{X}_{im}/T>0$
$\bar{X}_{im}<0$	$\bar{X}_{im}/\sigma(X_{im})<0$, $IR(X_{im})<0$, $\bar{X}_{im}/T<0$	$\bar{X}_{im}/\sigma(X_{im})<0$, $IR(X_{im})>0$, $\bar{X}_{im}/T<0$

Top left case: a decision that brings positive excess return while increasing the relative risk will lead to positive absolute, component and contributed IRs.

Bottom left case: a decision that leads to negative excess return while increasing the relative risk to the portfolio will reflect negatively in absolute, component and contributed IRs.

Top right case: a negative component IR can result from a decision that has a positive absolute IR when there are positive contributions to excess return together with decreases in the relative risk. However, the contributed IR the decision brings to the whole portfolio is positive. Therefore, it can be seen that given a negative risk weight, a value-adding decision can reflect poorly on IR (Xim) but positively on ${}^{\overline{X\imath m}}/_{T}$

Bottom right case: a positive component IR can exist while the absolute IR a decision brings is negative if the decision leads to negative excess return but a decrease in relative risk. In this case, the contributed information ratio is negative.

It can be seen that from the two cases on the right where the risk weight is negative, component IR and absolute IR tend to give conflicting results. It is also noticeable that with a negative risk weight, the absolute IR is in accordance with the contributed IR. (Bertrand 2008) For portfolio managers, the most optimal case would be the top right case where the risk weight is negative and the excess return is positive. Followed by the top left case where both risk weight and excess return are positive. The least desirable quadratic would be the bottom left case where the risk weight is positive and excess return is negative, while the second least optimal case is the bottom right case where both the risk weight and excess return are negative.

4.0 Analysis

4.1 Methodology

The analysis part of this project will test our hypothesis that applying the tracking-error variant optimal weights to a portfolio will improve the information ratio of the portfolio measured by applying the above equations.

We will start with calculating the expected excess return of the portfolio, the attribution, risk attribution and the three levels of information ratios including the absolute, component and contributed information ratios for the portfolio as it is, with the current weights. Then we will perform a tracking-error variance optimization on the weights and with these news weights, re-calculate the different performance measures again and compare these finding with what we get from the current weights. The optimization is based on the following equation:

$$\min_{z_p} T^2 = (z_p - z_b)' V (z_p - z_b)$$

$$\textit{with respect to}: (z_p - z_b)' R = \text{G}$$

$$(z_p - z_b)' e = 0$$

Where z_p is a vector of the sector weights of the portfolio, z_b is a vector of the sector weights of the benchmark, V is the covariance matrix of the sector returns, R is a vector of the expected returns of the sectors, e is a unity vector and G is the sought after excess return of the portfolio compared to the benchmark.

By optimizing the weights of the portfolio, we optimize the sector weights. The reasons that we choose to optimize the sector weights (as opposed to the individual holding weights) are as follows:
Firstly, to do the optimization we need the covariance matrix of the returns. If we wanted to optimize the weight of the individual holdings, we would need the covariance matrix of the individual holdings, resulting in a need of more data than possible, because for the covariance matrix to be stable, we would need $\frac{n(n-1)}{2}$ numbers of observation, and with a sample of approximately 200 holdings, using monthly data, this would require more than 1600 years worth data. By using the sectors n is 10 and number of observations needed reduces to around 60 (or five years when using monthly data).
Secondly, by using sectors, the issue of a portfolio that is very different in size compared to the benchmark, that being a lot larger or vastly smaller, is evaded. In our test, we assume that the holdings within the sector remains the same, but their weights will be adjusted so the relative weights of the holdings within the sector are kept intact, but the total weight off the sector will have changed.

The only exception is with sectors that have 0 % weight in the portfolio. Since the portfolio will not have any holdings within these sectors, we will use the benchmark holdings for these sectors and adjust them according to the overall sector weight.
The last reason to optimize sectors has to do with Investment Policy Statements (IPS) and constraints in these.
Most portfolio managers have an IPS they need to comply with when making investment decisions. These constraints could be no shorting, a max % holding on individual stocks, or minimum number of stocks that needs to be invested in. By optimizing the sector weights, the "no shorting" or the "max % holding" in individual stocks will not be a problem. And since we optimize by minimizing the tracking-error, compared to the benchmark, the weightings of the portfolio compared to the benchmark, will only differ by the benchmark enough to achieve the required excess return, and the minimum number of sector constraint should not pose a problem.

To ensure the most robust test results, we will test our results in three ways:
We will use three different time periods to see if we got our results because the time period happen to be particularly favourable for our test or if we get the same results regardless of time period chosen. We will also compare our result with an optimization by the more traditional mean-variance optimization (Grauer et al. 1990). Since the optimization and testing in general depends greatly on the expected returns, we will also perform a sensitivity analysis to see how sensitive our findings are to the estimate of the expected return as well as to be able to provide a confidence interval for the optimal sector weights for the portfolio.

4.2 Data

To do the test, we will focus on the Canadian Equity asset class of the SIAS Fund and therefore perform the optimization on the sectors of the Canadian Equity portfolio. As the benchmark, we will use the iShares ETF that tracks the S&P/TSX Capped Composite Index, the XIC. In order to avoid the management fee of the ETF to affect our results, we're using the weights and returns of the individual holdings in the ETF to get the overall return. Any holdings the ETF have that are traded on a foreign exchange, we changed to the same stock traded on the Toronto Stock Exchange to avoid currency to affect our results. For price data we use end-of month prices of individual stocks adjusted for dividends for the time period 31/5 2001 – 30/6-2011 (122 months.) We then calculate the monthly return for each stock and use the average of the monthly returns as the expected returns.

We use a total of 195 stocks, divided into the 10 sectors based on the MSCI segregation.
The targeted excess return for the SIAS Canadian Equity Portfolio is 150 bps as stated in the fund's IPS (SIAS IPS 2009, page 22). For the portfolio there is also the constraint that it must be invested in a minimum of seven out of the 10 sectors, and that none of these seven sectors can have less than 50 % weight compared to the benchmark weight. There are also constraints regarding the individual holdings, but as mentioned above, when optimizing the sectors, the individual holding constraints are not an issue.

For calculating the different time periods, we divide the 10 year time period into two, and re-do the calculations for the time periods 31/5 2001 – 31/5 2006 and 30/6 2006 - 30/6 2011. For the sensitivity analysis, we simulate the returns with standard normal random variables to see how much the result of the optimization, the sector weights of the portfolio, will differ depending on the input. For benchmark and portfolio weights, we are using the weights of both as of June 30th 2011. This is so, in case the analysis shows that changes are needed in the portfolio weights, the weights are up to date.

4.3 Results

4.3.1 No optimization

Before optimizing the portfolio, we calculated the return attribution, risk attribution and information ratio for the portfolio with the current weights, using the expected returns to predict how the portfolio will perform relative to the benchmark.

Table 1 – Portfolio and benchmark sector weights as of June 30th 2011

	Portfolio	Benchmark	Difference
Consumer Discretionary	2.25	3.64	-1.39
Consumer Staples	5.27	2.70	2.57
Energy	27.26	24.34	2.92
Financials	29.91	31.23	-1.32
Health Care	0.00	1.55	-1.55
Industrials	0.00	5.18	-5.18
Information Technology	1.24	1.83	-0.59
Materials	25.52	22.76	2.75
Telecommunication Services	5.56	4.77	0.79
Utilities	2.98	1.99	0.99
Average absolute difference			2.00

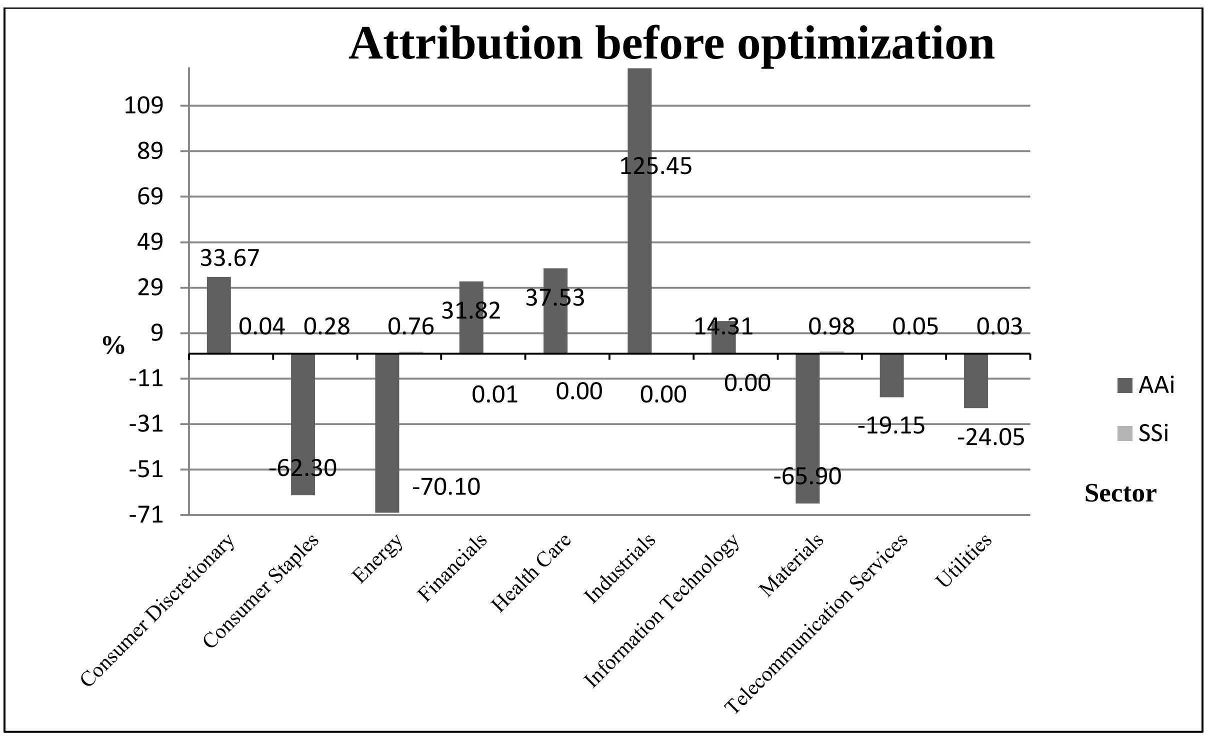
In table 1 it can be seen that the current sector weights of the portfolio are quite different than those of the benchmark. In particular, notice the large underweight in the industrial sector and relatively large over-weights in the consumer staples, energy and materials sectors. Since these differences will increase the tracking error, our hypothesis before doing the optimization is that the difference in the weights will decrease.

Table 2 – The expected performance of the portfolio if the sector weights are not changed

Expected Return Benchmark	24.29	
Expected Return Portfolio	27.72	
Expected Excess Return	3.42	
Asset Allocation Effect	1.29	
Stock Selection Effect	2.14	
Tracking Error	17.28	
Information Ratio Portfolio	0.88	
Decomposition of the Information Ratio		
Stand alone Information Ratio	0.0041	
Contributed Information Ratio	0.0099	
	SS	**AA**
Component Information Ratio	0.0114	0.0001

The expected excess return of the Canadian equity portfolio is positive, with both asset allocation and stock selection being positive as well.

Figure 3 – The asset and selection effect of sectors



From the chart above, it can be seen that the majority of the positive asset allocation comes from the zero weighting in the industrial sector, while the overweight in materials, energy and consumer staples contributed to a big negative asset allocation. For stock selection it's positive for all sectors except industrials and health care, where the figures are zero as the portfolio doesn't hold any stocks and information technology where the selection effect is negative.

Despite the positive expected return, the expected tracking error is 17.28, which is quite large, meaning that the portfolio tends to have more extreme results than the benchmark does. Thus, if there is a bad quarter or month, there is a higher possibility that the portfolio will significantly underperform the benchmark. Besides, a large tracking error also leads to a relatively small information ratio of 0.88.

After performing the breakdown of information ratio into the three levels, we can see the portfolio without applying tracking-error variance optimal weights is located in the top left case in the quadratic graph introduced by Bertrand (2008), with the stand alone IR being 0.0041, component IR being 0.0114 the majority of which comes from selection effect and contributed IR being 0.0099.

4.3.2 The optimization

The optimization returned the following weights for the portfolio as showcased in table 3.

Table 3 – The weights of the portfolio before and after the optimization and the weights of the benchmark

	Current Portfolio weights	Change	TEV optimal weights	Current Benchmark weights	Difference between TEV weights and benchmark weights
Consumer Discretionary	2.25	1.16	3.42	3.64	-0.22
Consumer Staples	5.27	-2.87	2.40	2.70	-0.30
Energy	27.26	-2.91	24.36	24.34	0.02
Financials	29.91	1.63	31.54	31.23	0.30
Health Care	0.00	1.74	1.74	1.55	0.19
Industrials	0.00	5.10	5.10	5.18	-0.08
Information Technology	1.24	0.39	1.63	1.83	-0.20
Materials	25.52	-2.75	22.77	22.76	0.01
Telecommunication Services	5.56	-1.29	4.27	4.77	-0.50
Utilities	2.98	-0.21	2.78	1.99	0.78
Average absolute difference					0.26

As anticipated, the optimized weights are more converged to the benchmark weights. This is clear when comparing the average of the absolute difference between the portfolio and benchmark sector weights for the current and optimized portfolio weights. For the optimized weights the average is 0.26 (table 3) compared to 2.00 (table 1) before.

The change is most significant for the four sectors that in the current sector weight are the most over- and underweight prior to the optimization.

The optimization is based on the expected return of each sector, assuming equal weight in all stocks and the excess return calculated is 150 bps. using the new weight and the expected return of the sectors.

However, in the portfolio, the holdings are not equally weighted within the sectors, as assumed in the optimization, and the actual expected return is thus a little different than what has been calculated with the optimization. Nevertheless, this should not affect the other calculations, as the most important variable is the sector weights.

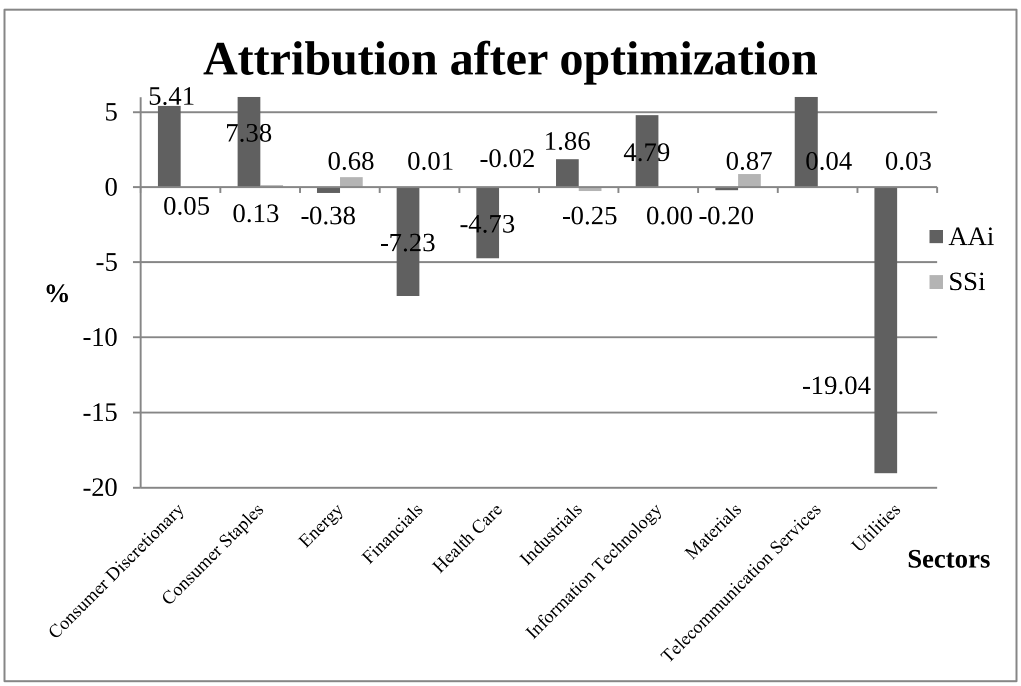
The calculated expected performance measures if the optimized weights are applied to the portfolio can be seen in the table below.

Table 4 – Expected performance, attribution and information ratio if optimized weights are applied.

Expected Return Benchmark	24.290	
Expected Return Portfolio	24.730	
Expected Excess Return	0.440	
Asset Allocation Effect	0.075	
Stock Selection Effect	1.531	
Tracking Error	0.451	
Information Ratio Portfolio	2.278	
Decomposition of the Information Ratio		
Stand alone Information Ratio	0.013	
Contributed Information Ratio	0.178	
	SS	**AA**
Component Information Ratio	0.038	0.002

From the table it is apparent that the optimization improves the measures. Although the expected excess return is slightly smaller than before, the tracking error is a lot smaller and thus the information ratio is much bigger. Looking at the asset allocation and selection effect, it is also obvious that the weights are much more similar between the portfolio and benchmark, as the asset allocation effect is a lot smaller.

Figure 4 -The Asset Allocation and Stock Selection effects on a sector level after applying optimized weights.



We also calculated the three levels of the information ratio using the optimized weights. It can be seen that although the portfolio is not moved to a better case (top right case as explained in section 3.5 and in figure 2), all three levels have improved with standalone IR being 0.0132, component IR being 0.0400 and contributed IR being 0.1780. It is also worth noting that by applying tracking-error variance optimal weights, the component IR that is attributed to asset allocation has improved drastically from $6.67 \cdot 10^{-5}$ to 0.0015.

4.3.3 Comparison with different time periods

To further verify our findings that applying tracking-error variance optimal weights to each sectors, will improve the information ratio, we re-did the calculations on two sub periods of 31/5/2011-31/5/2006 and 30/6/2006 -30/6/2011 respectively. We found that this new test supports our findings in the initial calculation. In the first time period from 2001 to 2006 the stand alone IR increases from 0.0038 to 0.0267, component IR from 0.0052 to 0.0431 and contributed IR from 0.0146 to 0.5241. It also justifies the finding that it is the part of the component IR that is attributed to asset allocation that explains the majority of the improvement.

Table 5- The decomposed information for the current and optimized weights for the time period 2001-2006

Current Portfolio Weights time period 2001-2006			**TEV optimized Portfolio Weights 2001-2006**		
Stand alone IR	0.0038		**Stand alone IR**	0.0267	
Contributed IR	0.0146		**Contributed IR**	0.5241	
	SS	**AA**		**SS**	**AA**
Component IR	0.00511	0.00004	**Component IR**	0.0383	0.0048

The results are also supported in the second time period from 2006 to 2011, where the standalone IR improves from 0.0048 to 0.0113 after applying the tracking-error variance optimal weights, component IR from 0.0134 to 0.0327 and contributed IR from 0.0058 to 0.1096. Again, it is apparent that the improvement in component IR mainly comes from a better asset allocation contribution.

Table 6- The decomposed information ratio for the current and optimized weights for the time period 2006-2011

Current Portfolio Weights time period 2006-2011			**TEV optimized Portfolio Weights 2006-2011**		
Stand alone IR	0.0048		**Stand alone IR**	0.0113	
Contributed IR	0.0058		**Contributed IR**	0.1096	
	SS	**AA**		**SS**	**AA**
Component IR	0.0132	0.0001	**Component IR**	0.0312	0.0015

4.3.4 Sensitivity Analysis

Since the tracking-error variance optimization is based on the estimated expected returns, we did a sensitivity analysis to determine how much the weights would alter with respect to the changes in estimated returns. To do this sensitivity analysis, we generated standard random variables for returns on a stock level, and then combined these to achieve an estimate for the expected sector returns. We then did 50 simulations in order to estimate the standard deviation.

In this analysis we focused solely on the change in the recommended portfolio weightings when changing the expected returns. The benchmark and target excess return remained the same throughout the simulations.

Via the simulation we got the following standard deviations for the change in the sector weight.

Table 7 – The standard deviation of sector weights based on simulation and the standard deviation of the sector returns, based on the variance-covariance matrix

	σ of the weights	**σ of sector returns (from the actual expected returns)**
Consumer Discretionary	0.55	0.75
Consumer Staples	0.81	0.43
Energy	0.32	2.84
Financials	0.39	1.47
Health Care	0.85	0.26
Industrials	0.58	0.87
Information Technology	0.97	0.52
Materials	0.23	5.17
Telecommunication Services	0.98	0.21
Utilities	0.80	0.34

The standard deviations for every sector are below one, however there are sectors where the optimal weight deviates less when the expected return changes. When comparing the standard deviations of the weights to the standard deviation of the sector returns (of the actual expected returns, not the simulated), it becomes apparent that the sectors with the highest standard deviations for the returns are the most 'stable' when it comes to determining optimal weight.

This is understandable, since it's the tracking-error variance that is minimized, and to minimize this, the most volatile sectors needs to be the ones that most closely match the benchmark weight, and thus the weighting of these will depend less on the estimated returns.

The covariance matrix changes each time the simulation is run, however the three sectors with the highest standard deviation are the sectors with the largest number of holdings in them, it is therefore likely that these will be the most volatile in the estimation.

This sensitivity analysis can also be used to pose a lower and upper bound on the weights of each sector. For our bounds, we used two standard deviations to create a confidence interval of 95 %, meaning that there is a 95 % probability that the tracking-error variance optimal weights for the SIAS Canadian Equity portfolio are within the intervals.

Table 8 – The suggested optimal weights of the SIAS Canadian Equity Portfolio

	Lower Bound (-2σ)	**TEV Optimal Portfolio weights**	**Upper Bound (+2σ)**
Consumer Discretionary	2.32	3.42	4.52
Consumer Staples	0.77	2.40	4.02
Energy	23.71	24.36	25.01
Financials	30.75	31.54	32.32
Health Care	0.03	1.74	3.45
Industrials	3.93	5.10	6.26
Information Technology	0	1.63	3.58
Materials	22.31	22.77	23.23
Telecommunication Services	2.32	4.27	6.22
Utilities	1.18	2.78	4.37

4.3.5 Comparison to Mean-Variance Optimization

In order to prove that tracking-error variance is a better measure to use for portfolio optimization, even in the case where the portfolio manager is solely concerned with the excess return, we did a traditional mean-variance optimization on the sector weights.

The overall criterion is to maximize the expected return for each level of overall portfolio variance, independent of a benchmark. We used a simple mean-variance model, where the assumption is that there is no risk-free borrowing and lending. We didn't apply the constraint of no-negative weights because the there is no such constraint in the tracking-error variance optimization.

The MV optimization is performed based on the following equation (Grauer et al. 1990)

$$\max \mathrm{E}\left(\mathrm{r_p}\right) = \sum_{\mathrm{j}} \mathrm{x_j}\mathrm{E}\left(\mathrm{r_j}\right)$$

With respect to $\sigma_p^2 = \sum_j \sum_i x_j x_i \sigma_i \sigma_j \;\; and \;\; \sum_j x_j = 1$

Where x_i and x_j are the sector weights of sector i and j respectively, $E(r_j)$ is the expected return of sector j, $E(r_p)$ is the expected return of the portfolio and σ_j is the standard deviation of sector j.

The table below shows the weights of the mean-variance optimization, compared to the current weights of the portfolio and the tracking-error variant optimal weights.

Table 9 – Current benchmark and portfolio weights compared to the optimal weights from TEV and MV optimization

	Benchmark weight	Current Portfolio Weights	TEV optimal portfolio weights	MV optimal portfolio weights
Consumer Discretionary	3.64	2.25	3.42	-27.48
Consumer Staples	2.70	5.27	2.40	-8.03
Energy	24.34	27.26	24.36	-0.72
Financials	31.23	29.91	31.54	21.70
Health Care	1.55	0.00	1.74	44.07
Industrials	5.18	0.00	5.10	-6.94
Information Technology	1.83	1.24	1.63	-11.21
Materials	22.76	25.52	22.77	1.01
Telecommunication Services	4.77	5.56	4.27	18.56
Utilities	1.99	2.98	2.78	69.04

From table it is apparent that the mean-variance optimal weights are a lot more extreme, with five sector getting negative weights. Without looking at the expected performance or considering the benchmark weights, the weights given by the mean-variance optimization do not seem as easy to implement as the weights given by the tracking-error optimization. This has much to do with the different risk measure that are minimized in the optimizations.

In the mean-variance universe, the risk measure is the overall variance of a sector, and the trade off is therefore between the absolute return and risk of the individual sectors and the portfolio as a whole. There is no benchmark so the optimization depends solely on the covariance matrix. For the tracking-error variance optimal portfolios, both the return and risk are relative parameters. If the targeted excess return compared to benchmark was zero, the tracking-error variance optimization would return the benchmark weights as optimal, so it is by setting the targeted outperformance level above zero that the deviation from benchmark weightings will occur in the tracking-error space. However, the deviation will always be only just enough to achieve the targeted excess return, and the optimal weightings of a tracking-error variant portfolio, will therefore usually be a lot less extreme than those given by the mean-variance optimization.

The expected performance and information ratio for the MV optimal portfolio can be seen in the table below

Table 10 – The expected performance figures for the MV optimal portfolio

Expected Return Benchmark	24.290	
Expected Return Portfolio	13.440	
Expected Excess Return	-10.846	
Asset Allocation Effect	-17.008	
Stock Selection Effect	-0.218	
Tracking Error	189.174	
Information Ratio Portfolio	-0.509	
Decomposition of the Information Ratio		
Stand alone Information Ratio	-0.012	
Contributed Information Ratio	-0.005	
	SS	**AA**
Component Information Ratio	-0.032	-0.0001

When we look at the expected performance of the portfolio applying the mean-variance optimized weights, then it becomes even more obvious that the mean variance optimization doesn't do a portfolio manager, who is measured relative to a benchmark, any good. Even though the expected return is positive, everything else is negative. -The expected excess return, the asset allocation and stock selection effect and most importantly the information ratio. Furthermore, the expected tracking error is large, suggesting more extreme relative returns compared to the benchmark.

When decomposing the information ratio of the mean-variance optimization, we find that the portfolio is moved to the bottom left case in the quadratic (see figure 2) which is much less optimal than our portfolio as it is now or that with tracking-error variance optimal weights. It generates negative information ratios at three levels with stand alone IR being -0.0117, component IR being -0.0322 and contributed IR being -0.0046. It is derived that although mean-variance frontier offers the most efficient combination of absolute risk and return, it fails to provide an optimal solution when it comes to relative measures that most portfolio managers are evaluated by.

5.0 Conclusion

We have tested and applied the theory developed by Bertrand (2008) as expressed in the article "Risk-adjusted performance attribution and portfolio optimizations under tracking error-constraints". We calculated the three level information ratios for the SIAS Canadian Equity portfolio using the ishares ETF, XIC as a benchmark and weights of both as of June 30th 2011. The calculations are based on expected return, which is the historical average of 10 years monthly return. We found that the portfolio had a positive expected excess return that was well above the targeted excess return, as per the investment policy statement. But the tracking-error was big and thus causing the risk-adjusted return, in form of the information ratio to be quite small.

The tracking-error variance optimization is performed on the sector weights of the portfolio and we recalculated the expected excess return and information ratios. The expected excess return was smaller, however, as the tracking-error variance is minimized, the information ratio dramatically improved. This is because by performing the tracking-error variance optimization we are reducing the relative risk to a minimum with respect to the required excess return.

We repeated the exercise for two time periods of five years each. Both confirmed our finding, by optimizing the sector weights with respect to the tracking-error variance, the information ratio improves. Since the optimization is so reliant on the estimated expected returns, we simulated random return numbers to use those as the expected returns instead. By doing this we saw that the sectors that have more volatile returns' weight changes less when the returns change than the sectors where the returns are less volatile.

We used the standard deviation of the sector weights to come up with a recommended weight for each sector together with a 95 % confidence interval, so that with 95 % probability, the tracking-error variance optimal weights are within the interval. The findings can be seen in the table below.

Table 11 – The suggested optimal weights of the SIAS Canadian Equity Portfolio

	Lower Bound (-2σ)	**TEV Optimal Portfolio weights**	**Upper Bound (+2σ)**
Consumer Discretionary	2.32	3.42	4.52
Consumer Staples	0.77	2.40	4.02
Energy	23.71	24.36	25.01
Financials	30.75	31.54	32.32
Health Care	0.03	1.74	3.45
Industrials	3.93	5.10	6.26
Information Technology	0	1.63	3.58
Materials	22.31	22.77	23.23
Telecommunication Services	2.32	4.27	6.22
Utilities	1.18	2.78	4.37

In the end we compared the tracking-error variance findings to the mean-variance efficient weights, to test whether the tracking-error variance optimization is more suitable for portfolio managers in general. The mean-variance frontier optimizes with respect to absolute risk and not relative risk, and thus, being as most portfolio managers are evaluated based on their relative performance, our hypothesis was that tracking-error variance optimization should be adopted instead of mean-variance.

Our findings supported this thesis. The weightings for all sectors are a lot more extreme when using the mean-variance optimization. The expected information ratio was also negative, as was the expected excess return.

Therefore, using the tracking-error optimization will improve the expected relative performance of the portfolio, and it should thus be adopted.

6.0 Reference List

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Investment Policy Statement for the Student Investment Advisory SIAS of 2009

APPENDIX

Appendix 1 : Code for calculating on raw data, TEV and MV optimization

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% This a script that will calculate the return of a portfolio, the excess
% return compared to a benchmark, the risk-adjusted return - the
% information ratio.
% Then it performs a tracking-error variance optimization, based on a
% constraint to outperform the benchmark - ie to achieve the required
% outperformance while minimizing the tracking error compared to the
% benchmark.
% Authors:
% Christine Jakshoj: cja22@sfu.ca
% Meadow Wu: rwa31@sfu.ca
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% LOAD DATA
clear all
clear all
close all
clc
format compact

[prices]=xlsread('Data.xlsx','Prices'); % Load the prices
[qp] = xlsread('Data.xlsx','Portweights'); % load portfolio individual weights
[q] = xlsread('Data.xlsx','Benchweight'); % load benchmark individual weights
bench_weight = q';
port_weight = qp';

G = 0.15; % constraint outperformance from IPS to CE portfolio
% Turn the prices into returns
[nobs,nsec]=size(prices);

sec1 = 14; % Number of stocks in the first sector
sec2 = 9;
sec3 = 44;
sec4 = 34;
sec5 = 4;
sec6 = 15;
sec7 = 6;
sec8 = 55;
sec9 = 4;
sec10 = 10;

secs = [sec1;sec2;sec3;sec4;sec5;sec6;sec7;sec8;sec9;sec10];
if  sum(secs) ~= nsec
    error('the sum number of holdings in the sectors must match the total number of
securities');
end
%% CALCULATE RETURNS

returns = zeros(nobs-1,nsec); % pre-assign size for faster code
for idx = 1:nsec
returns(:,idx) = log(prices(2:end,idx)./prices(1:end-1,idx));
end
exp_ret = mean(returns);
```

```
% Calculate the expected return for each sector
ret_sec = zeros(nobs-1,10);
for idx = 1:nobs-1
    ret_sec(idx,:) = [sum(returns(idx,1:secs(1,1)))
sum(returns(idx,1+secs(1,1):sum(secs(1:2,1))))
sum(returns(idx,1+sum(secs(1:2,1)):sum(secs(1:3,1))))
sum(returns(idx,1+sum(secs(1:3,1)):sum(secs(1:4,1))))
sum(returns(idx,1+sum(secs(1:4,1)):sum(secs(1:5,1))))
sum(returns(idx,1+sum(secs(1:5,1)):sum(secs(1:6,1))))
sum(returns(idx,1+sum(secs(1:6,1)):sum(secs(1:7,1))))
sum(returns(idx,1+sum(secs(1:7,1)):sum(secs(1:8,1))))
sum(returns(idx,1+sum(secs(1:8,1)):sum(secs(1:9,1))))
sum(returns(idx,1+sum(secs(1:9,1)):sum(secs(1:10,1))))];
end

exp_ret_sec = mean(ret_sec);

% Calculate the weight for each sector for portfolio and benchmark

weight_sec1b = sum(bench_weight(1,1:secs(1,1)));
weight_sec2b = sum(bench_weight(1,1+secs(1,1):sum(secs(1:2,1))));
weight_sec3b = sum(bench_weight(1,1+sum(secs(1:2,1)):sum(secs(1:3,1))));
weight_sec4b = sum(bench_weight(1,1+sum(secs(1:3,1)):sum(secs(1:4,1))));
weight_sec5b = sum(bench_weight(1,1+sum(secs(1:4,1)):sum(secs(1:5,1))));
weight_sec6b = sum(bench_weight(1,1+sum(secs(1:5,1)):sum(secs(1:6,1))));
weight_sec7b = sum(bench_weight(1,1+sum(secs(1:6,1)):sum(secs(1:7,1))));
weight_sec8b = sum(bench_weight(1,1+sum(secs(1:7,1)):sum(secs(1:8,1))));
weight_sec9b = sum(bench_weight(1,1+sum(secs(1:8,1)):sum(secs(1:9,1))));
weight_sec10b = sum(bench_weight(1,1+sum(secs(1:9,1)):sum(secs(1:10,1))));

% benchmark sector weights
bench_weight_sec =
[weight_sec1b;weight_sec2b;weight_sec3b;weight_sec4b;weight_sec5b;weight_sec6b;weig
ht_sec7b;weight_sec8b;weight_sec9b;weight_sec10b];

% portfolio sector weights
weight_sec1p = sum(port_weight(1,1:secs(1,1)));
weight_sec2p = sum(port_weight(1,1+secs(1,1):sum(secs(1:2,1))));
weight_sec3p = sum(port_weight(1,1+sum(secs(1:2,1)):sum(secs(1:3,1))));
weight_sec4p = sum(port_weight(1,1+sum(secs(1:3,1)):sum(secs(1:4,1))));
weight_sec5p = sum(port_weight(1,1+sum(secs(1:4,1)):sum(secs(1:5,1))));
weight_sec6p = sum(port_weight(1,1+sum(secs(1:5,1)):sum(secs(1:6,1))));
weight_sec7p = sum(port_weight(1,1+sum(secs(1:6,1)):sum(secs(1:7,1))));
weight_sec8p = sum(port_weight(1,1+sum(secs(1:7,1)):sum(secs(1:8,1))));
weight_sec9p = sum(port_weight(1,1+sum(secs(1:8,1)):sum(secs(1:9,1))));
weight_sec10p = sum(port_weight(1,1+sum(secs(1:9,1)):sum(secs(1:10,1))));

port_weight_sec =
[weight_sec1p;weight_sec2p;weight_sec3p;weight_sec4p;weight_sec5p;weight_sec6p;weig
ht_sec7p;weight_sec8p;weight_sec9p;weight_sec10p];

% Calculate the returns of bencmark and portfolio and excess return
ret_benchs = q'.*exp_ret;
```

```
ret_secb1 = sum(ret_benchs(1,1:secs(1,1)));
ret_secb2 = sum(ret_benchs(1,1+secs(1,1):sum(secs(1:2,1))));
ret_secb3 = sum(ret_benchs(1,1+sum(secs(1:2,1)):sum(secs(1:3,1))));
ret_secb4 = sum(ret_benchs(1,1+sum(secs(1:3,1)):sum(secs(1:4,1))));
ret_secb5 = sum(ret_benchs(1,1+sum(secs(1:4,1)):sum(secs(1:5,1))));
ret_secb6 = sum(ret_benchs(1,1+sum(secs(1:5,1)):sum(secs(1:6,1))));
ret_secb7 = sum(ret_benchs(1,1+sum(secs(1:6,1)):sum(secs(1:7,1))));
ret_secb8 = sum(ret_benchs(1,1+sum(secs(1:7,1)):sum(secs(1:8,1))));
ret_secb9 = sum(ret_benchs(1,1+sum(secs(1:8,1)):sum(secs(1:9,1))));
ret_secb10 = sum(ret_benchs(1,1+sum(secs(1:9,1)):sum(secs(1:10,1))));

ret_sec_bench = [ret_secb1 ret_secb2 ret_secb3 ret_secb4 ret_secb5 ret_secb6
ret_secb7 ret_secb8 ret_secb9 ret_secb10];

ret_ports = qp'.*exp_ret;
ret_secp1 = sum(ret_ports(1,1:secs(1,1)));
ret_secp2 = sum(ret_ports(1,1+secs(1,1):sum(secs(1:2,1))));
ret_secp3 = sum(ret_ports(1,1+sum(secs(1:2,1)):sum(secs(1:3,1))));
ret_secp4 = sum(ret_ports(1,1+sum(secs(1:3,1)):sum(secs(1:4,1))));
ret_secp5 = sum(ret_ports(1,1+sum(secs(1:4,1)):sum(secs(1:5,1))));
ret_secp6 = sum(ret_ports(1,1+sum(secs(1:5,1)):sum(secs(1:6,1))));
ret_secp7 = sum(ret_ports(1,1+sum(secs(1:6,1)):sum(secs(1:7,1))));
ret_secp8 = sum(ret_ports(1,1+sum(secs(1:7,1)):sum(secs(1:8,1))));
ret_secp9 = sum(ret_ports(1,1+sum(secs(1:8,1)):sum(secs(1:9,1))));
ret_secp10 = sum(ret_ports(1,1+sum(secs(1:9,1)):sum(secs(1:10,1))));

ret_sec_port = [ret_secp1 ret_secp2 ret_secp3 ret_secp4 ret_secp5 ret_secp6
ret_secp7 ret_secp8 ret_secp9 ret_secp10];

exp_ret_bench = sum(ret_sec_bench*bench_weight_sec);
exp_ret_port = sum(ret_sec_port*port_weight_sec);
alpha = exp_ret_port - exp_ret_bench;

% Calculate the attribution

AAi = (port_weight_sec - bench_weight_sec)'.*(ret_sec_bench - exp_ret_bench); %
Asset allocation for each sector
AA = sum(AAi); % overall asset allocation

SSi = port_weight_sec'.*(ret_sec_port - ret_sec_bench); % Stock selection for each
sector
SS = sum(SSi); % total stock selection

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% RISK ATTRIBUTION

% Risk asset allocation and stock selection
%A = cov((ret_sec_bench-exp_ret_bench),(ones(1,10)* alpha));
%covar(AAi,alpha) =(port_weight_sec - bench_weight_sec)*A(1,1);
%B = cov((ret_sec_bench-ret_sec_port),(ones(1,10)* alpha));
%covar(SSi,alpha) = port_weight_sec*B(1,1);

% Calculate the variance-covariance matrix
V = cov(ret_sec);
```

```
% Tracking error
T =sqrt((port_weight_sec-bench_weight_sec)'*V*(port_weight_sec-bench_weight_sec));

A = cov((ret_sec_bench-exp_ret_bench),(ones(1,10)* alpha));
covar_AAS = (port_weight_sec - bench_weight_sec)*A(1,1);

B = cov((ret_sec_port-ret_sec_bench),(ones(1,10)* alpha));
covar_SSS = port_weight_sec*B(1,1);
%% INFORMATION RATIO

IR_AAi = ((port_weight_sec - bench_weight_sec)'.*(ret_sec_bench-
exp_ret_bench))'/(covar_AAS/T);
IR_SSi = (port_weight_sec'.*(ret_sec_port-ret_sec_bench))'/(covar_SSS/T);
IR_AAi = IR_AAi(:,6);
IR_SSi = IR_SSi(:,4);

Xi = [AAi'; SSi'];
stand_alone_IR = mean(Xi)/std(Xi);
% component_IR = (1/(corrcoef(Xi,alpha*ones(20,1))))*stand_alone_IR;
contributed_IR = mean(Xi)/T;

C = cov(AAi,alpha*ones(1,10));
correlationAAS = C(1,1)/std(AAi);
D = cov(SSi,alpha*ones(1,10));
correlationSSS = D(1,1)/std(SSi);
component_IRAA = (1/correlationAAS)*stand_alone_IR;
component_IRSS = (1/correlationSSS)*stand_alone_IR;

IRp = (((std(AAi)*C(1,1))/T)*component_IRAA)
+(((std(SSi)*D(1,1))/T)*component_IRSS);

%% TR OPTIMIZATION
e = ones(10,1);
a = exp_ret_sec*inv(V)*exp_ret_sec';
b = e'*inv(V)*exp_ret_sec';
c = e'*inv(V)*e;
R0 = b/c;
R1 = a/b;
D = G/(R1-R0);
q0 = V\(e/c);
q1 = V\(exp_ret_sec'/b);

opt_sec_weight = bench_weight_sec + D*(q1-q0);

% Adjust the holding weights of the portfolio
opt_weight_p1 =
(opt_sec_weight(1,1)/port_weight_sec(1,1))*port_weight(1,1:secs(1,1));
opt_weight_p2 =
(opt_sec_weight(2,1)/port_weight_sec(2,1))*port_weight(1,1+secs(1,1):sum(secs(1:2,1
)));
opt_weight_p3 =
(opt_sec_weight(3,1)/port_weight_sec(3,1))*port_weight(1,1+sum(secs(1:2,1)):sum(sec
s(1:3,1)));
```

```
opt_weight_p4 =
(opt_sec_weight(4,1)/port_weight_sec(4,1))*port_weight(1,1+sum(secs(1:3,1)):sum(sec
s(1:4,1)));
opt_weight_p5 =
(opt_sec_weight(5,1)/bench_weight_sec(5,1))*bench_weight(1,1+sum(secs(1:4,1)):sum(s
ecs(1:5,1)));
opt_weight_p6 =
(opt_sec_weight(6,1)/bench_weight_sec(6,1))*bench_weight(1,1+sum(secs(1:5,1)):sum(s
ecs(1:6,1)));
opt_weight_p7 =
(opt_sec_weight(7,1)/port_weight_sec(7,1))*port_weight(1,1+sum(secs(1:6,1)):sum(sec
s(1:7,1)));
opt_weight_p8 =
(opt_sec_weight(8,1)/port_weight_sec(8,1))*port_weight(1,1+sum(secs(1:7,1)):sum(sec
s(1:8,1)));
opt_weight_p9 =
(opt_sec_weight(9,1)/port_weight_sec(9,1))*port_weight(1,1+sum(secs(1:8,1)):sum(sec
s(1:9,1)));
opt_weight_p10 =
(opt_sec_weight(10,1)/port_weight_sec(10,1))*port_weight(1,1+sum(secs(1:9,1)):sum(s
ecs(1:10,1)));

opt_qp =
[opt_weight_p1';opt_weight_p2';opt_weight_p3';opt_weight_p4';opt_weight_p5';opt_wei
ght_p6';opt_weight_p7';opt_weight_p8';opt_weight_p9';opt_weight_p10'];

opt_ret_ports = opt_qp'.*exp_ret;
opt_ret_secp1 = sum(opt_ret_ports(1,1:secs(1,1)));
opt_ret_secp2 = sum(opt_ret_ports(1,1+secs(1,1):sum(secs(1:2,1))));
opt_ret_secp3 = sum(opt_ret_ports(1,1+sum(secs(1:2,1)):sum(secs(1:3,1))));
opt_ret_secp4 = sum(opt_ret_ports(1,1+sum(secs(1:3,1)):sum(secs(1:4,1))));
opt_ret_secp5 = sum(opt_ret_ports(1,1+sum(secs(1:4,1)):sum(secs(1:5,1))));
opt_ret_secp6 = sum(opt_ret_ports(1,1+sum(secs(1:5,1)):sum(secs(1:6,1))));
opt_ret_secp7 = sum(opt_ret_ports(1,1+sum(secs(1:6,1)):sum(secs(1:7,1))));
opt_ret_secp8 = sum(opt_ret_ports(1,1+sum(secs(1:7,1)):sum(secs(1:8,1))));
opt_ret_secp9 = sum(opt_ret_ports(1,1+sum(secs(1:8,1)):sum(secs(1:9,1))));
opt_ret_secp10 = sum(opt_ret_ports(1,1+sum(secs(1:9,1)):sum(secs(1:10,1))));

opt_ret_sec_port = [opt_ret_secp1 opt_ret_secp2 opt_ret_secp3 opt_ret_secp4
opt_ret_secp5 opt_ret_secp6 opt_ret_secp7 opt_ret_secp8 opt_ret_secp9
opt_ret_secp10];

opt_alpha = sum(exp_ret_sec*opt_sec_weight) - sum(exp_ret_sec*bench_weight_sec);
opt_alpha_dif = (opt_ret_sec_port*opt_sec_weight)- exp_ret_bench;

% Calculate the attribution

opt_AAi = (opt_sec_weight - bench_weight_sec)'.*(ret_sec_bench -exp_ret_bench ); %
Asset allocation for each sector
opt_AA = sum(opt_AAi); % overall asset allocation

opt_SSi = opt_sec_weight'.*(ret_sec_port - ret_sec_bench); % Stock selection for
each sector
opt_SS = sum(opt_SSi); % total stock selection
```

```
%% RISK ATTRIBUTION

% Tracking error
opt_T =sqrt((opt_sec_weight-bench_weight_sec)'*V*(opt_sec_weight-
bench_weight_sec));

opt_A = cov((ret_sec_bench-exp_ret_bench),(ones(1,10)* opt_alpha_dif));
opt_covar_AAS = (port_weight_sec - bench_weight_sec)*opt_A(1,1);

opt_B = cov((ret_sec_port-ret_sec_bench),(ones(1,10)* opt_alpha_dif));
opt_covar_SSS = opt_sec_weight*opt_B(1,1);
%% INFORMATION RATIO

opt_IR_AAi = ((opt_sec_weight - bench_weight_sec)'.*(ret_sec_bench-
exp_ret_bench))'/(opt_covar_AAS/opt_T);
opt_IR_SSi = (opt_sec_weight'.*(opt_ret_sec_port-
ret_sec_bench))'/(opt_covar_SSS/opt_T);
opt_IR_AAi = opt_IR_AAi(:,6);
opt_IR_SSi = opt_IR_SSi(:,4);

opt_Xi = [opt_AAi'; opt_SSi'];
opt_stand_alone_IR = mean(opt_Xi)/std(opt_Xi);
opt_contributed_IR = mean(opt_Xi)/opt_T;

opt_C = cov(opt_AAi,opt_alpha*ones(1,10));
opt_correlationAAS = opt_C(1,1)/std(opt_AAi);
opt_D = cov(opt_SSi,opt_alpha_dif*ones(1,10));
opt_correlationSSS = opt_D(1,1)/std(opt_SSi);
opt_component_IRAA = (1/opt_correlationAAS)*opt_stand_alone_IR;
opt_component_IRSS = (1/opt_correlationSSS)*opt_stand_alone_IR;

opt_IRp = (((std(opt_AAi)*opt_C(1,1))/opt_T)*opt_component_IRAA)
+(((std(opt_SSi)*opt_D(1,1))/opt_T)*opt_component_IRSS);

%% MV OPTIMIZATION

a = e'*inv(V)*exp_ret_sec';
b = exp_ret_sec*inv(V)*exp_ret_sec';
c = e'*inv(V)*e;

MV_sec_weight =(inv(V)*e/c +(inv(V)*exp_ret_sec'-a/c*inv(V)*e))*100;

MV_alpha = sum(exp_ret_sec*MV_sec_weight) - exp_ret_bench;

% Calculate the attribution

MV_AAi = (MV_sec_weight - bench_weight_sec)'.*(ret_sec_bench - exp_ret_bench); %
Asset allocation for each sector
MV_AA = sum(MV_AAi); % overall asset allocation

MV_SSi = MV_sec_weight'.*(ret_sec_port - ret_sec_bench); % Stock selection for each
sector
MV_SS = sum(MV_SSi); % total stock selection
```

```
%% RISK ATTRIBUTION

% Tracking error
MV_T =sqrt((MV_sec_weight-bench_weight_sec)'*V*(MV_sec_weight-bench_weight_sec));

MV_A = cov((ret_sec_bench-exp_ret_bench),(ones(1,10)* MV_alpha));
MV_covar_AAS = (MV_sec_weight - bench_weight_sec)*MV_A(1,1);

MV_B = cov((ret_sec_port-ret_sec_bench),(ones(1,10)*MV_alpha));
MV_covar_SSS = MV_sec_weight*MV_B(1,1);
%% INFORMATION RATIO

MV_IR_AAi = ((MV_sec_weight - bench_weight_sec)'.*(ret_sec_bench-
exp_ret_bench))'/(MV_covar_AAS/MV_T);
MV_IR_SSi = (MV_sec_weight'.*(ret_sec_port-ret_sec_bench))'/(MV_covar_SSS/MV_T);
opt_MV_IR_AAi = MV_IR_AAi(:,10);
opt_MV_IR_SSi = MV_IR_SSi(:,10);

MV_Xi = [MV_AAi'; MV_SSi'];
MV_stand_alone_IR = mean(MV_Xi)/std(MV_Xi);
MV_contributed_IR = mean(MV_Xi)/MV_T;

MV_C = cov(MV_AAi,MV_alpha*ones(1,10));
MV_correlationAAS = MV_C(1,1)/std(MV_AAi);
MV_D = cov(MV_SSi,MV_alpha*ones(1,10));
MV_correlationSSS = MV_D(1,1)/std(MV_SSi);
MV_component_IRAA = (1/MV_correlationAAS)*MV_stand_alone_IR;
MV_component_IRSS = (1/MV_correlationSSS)*MV_stand_alone_IR;

MV_IRp = (((std(MV_AAi)*MV_C(1,1))/MV_T)*MV_component_IRAA)
+(((std(MV_SSi)*MV_D(1,1))/MV_T)*MV_component_IRSS);
```

Appendix 2: Code for Sensitivity Analysis

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Sensitivity analysis
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% LOAD DATA
clear all
clear all
close all
clc
format compact

[prices]=xlsread('Data.xlsx','Prices'); % Load the prices
[qp] = xlsread('Data.xlsx','Portweights'); % load portfolio individual weights
[q] = xlsread('Data.xlsx','Benchweight'); % load benchmark individual weights
bench_weight = q';
port_weight = qp';

G = 1.500; % constraint outperformance from IPS to CE portfolio
% Turn the prices into returns
[nobs,nsec]=size(prices);

sec1 = 14; % Number of stocks in the first sector
sec2 = 9;
sec3 = 44;
sec4 = 34;
sec5 = 4;
sec6 = 15;
sec7 = 6;
sec8 = 55;
sec9 = 4;
sec10 = 10;

secs = [sec1;sec2;sec3;sec4;sec5;sec6;sec7;sec8;sec9;sec10];
if  sum(secs) ~= nsec
    error('the sum number of holdings in the sectors must match the total number of 
securities');
end
%% CALCULATE RETURNS

% Create random returns to check sensitivty of our analysis to the expected
% return


returns = randn([nobs,nsec]);
exp_ret = mean(returns);
% Calculate the expected return for each sector
ret_sec = zeros(nobs-1,10);
for idx = 1:nobs-1
    ret_sec(idx,:) = [sum(returns(idx,1:secs(1,1)))
sum(returns(idx,1+secs(1,1):sum(secs(1:2,1))))
sum(returns(idx,1+sum(secs(1:2,1)):sum(secs(1:3,1))))
sum(returns(idx,1+sum(secs(1:3,1)):sum(secs(1:4,1))))
sum(returns(idx,1+sum(secs(1:4,1)):sum(secs(1:5,1))))
sum(returns(idx,1+sum(secs(1:5,1)):sum(secs(1:6,1))))
```

```
sum(returns(idx,1+sum(secs(1:6,1)):sum(secs(1:7,1))))
sum(returns(idx,1+sum(secs(1:7,1)):sum(secs(1:8,1))))
sum(returns(idx,1+sum(secs(1:8,1)):sum(secs(1:9,1))))
sum(returns(idx,1+sum(secs(1:9,1)):sum(secs(1:10,1))))];
end

exp_ret_sec = mean(ret_sec);

% Calculate the weight for each sector for portfolio and benchmark

weight_sec1b = sum(bench_weight(1,1:secs(1,1)));
weight_sec2b = sum(bench_weight(1,1+secs(1,1):sum(secs(1:2,1))));
weight_sec3b = sum(bench_weight(1,1+sum(secs(1:2,1)):sum(secs(1:3,1))));
weight_sec4b = sum(bench_weight(1,1+sum(secs(1:3,1)):sum(secs(1:4,1))));
weight_sec5b = sum(bench_weight(1,1+sum(secs(1:4,1)):sum(secs(1:5,1))));
weight_sec6b = sum(bench_weight(1,1+sum(secs(1:5,1)):sum(secs(1:6,1))));
weight_sec7b = sum(bench_weight(1,1+sum(secs(1:6,1)):sum(secs(1:7,1))));
weight_sec8b = sum(bench_weight(1,1+sum(secs(1:7,1)):sum(secs(1:8,1))));
weight_sec9b = sum(bench_weight(1,1+sum(secs(1:8,1)):sum(secs(1:9,1))));
weight_sec10b = sum(bench_weight(1,1+sum(secs(1:9,1)):sum(secs(1:10,1))));

% benchmark sector weights
bench_weight_sec =
[weight_sec1b;weight_sec2b;weight_sec3b;weight_sec4b;weight_sec5b;weight_sec6b;weig
ht_sec7b;weight_sec8b;weight_sec9b;weight_sec10b];

V = cov(ret_sec);

%% TR OPTIMIZATION
e = ones(10,1);
a = exp_ret_sec*inv(V)*exp_ret_sec';
b = e'*inv(V)*exp_ret_sec';
c = e'*inv(V)*e;
R0 = b/c;
R1 = a/b;
D = G/(R1-R0);
q0 = V\(e/c);
q1 = V\(exp_ret_sec'/b);

opt_sec_weight = bench_weight_sec + D*(q1-q0);
```

Appendix 3: Results with Raw data

		Data						Attribution		Risk Attribution		Information Ratio		overall return benchmark	24.29045	
Code com	Sector	Portfolio weight	Portfolio Return	Benchmark weight	Benchmark Return	Expected sector return	std variance sectors	AAi	SSi	Cov(aa,alpha)	cov(ss,alpha)	IR_AA	IR_SS	overall return portfolio	27.71787	
1	Consumer Discretionary	2.253812706	0.030950554	3.640943439	0.014893996	0.081716085	0.75	33.67336741	0.0361885	-0.027281836	0.001809059	-5716.95	26.04857	alpha	3.427423	
2	Consumer Staples	5.268791806	0.071874828	2.70208381	0.018097292	0.039026413	0.43	-62.30003734	0.2833426	0.050481548	0.004229081	10577.1	203.9508	T	17.28063	
3	Energy	27.26264066	0.318998949	24.34165331	0.291266807	0.54980534	2.84	-70.1013056	0.7560514	0.05744945	0.0218828	11901.57	544.208	IRp	0.880179	
4	Financials	29.90963595	0.26668341	31.23425693	0.26648912	0.345765498	1.47	31.82264022	0.0058111	-0.026052405	0.024007453	-5402.74	4.182877	Stand alone	0.004076	
5	Health Care	0	0	1.545683536	0.011814757	0.042724574	0.26	37.5270841	0	-0.030400224	0	-6371.23	0	Contributed	0.009917	
6	Industrials	0	0	5.175177467	0.048899473	0.136049809	0.87	125.4543171	0	-0.101784453	0	-21299.2	0		SS	AA
7	Information Technology	1.242401803	0.012386696	1.831921227	0.013206978	0.019493469	0.52	14.31190531	-0.0010191	-0.011594561	0.000997234	-2429.83	-0.73357	Component IR	0.011373	6.67E-05
8	Materials	25.51600135	0.402847343	22.76162125	0.364530576	0.88534717	5.17	-65.90107157	0.9776907	0.054172649	0.020480831	11188.47	703.7445			
9	Telecommunication Services	5.56375607	0.039177243	4.774444699	0.030007883	0.023885189	0.21	-19.14904148	0.0510161	0.015524033	0.004465839	3251.062	36.72152	AA	1.290967	
10	Utilities	2.98295965	0.028108984	1.992214335	0.018932217	0.099108949	0.34	-24.04689084	0.0273739	0.019485799	0.002394321	4082.603	19.70383	SS	2.136455	

Appendix 4: Results with TEV optimization

		Data					Attribution		Risk Attribution		Information Ratio				
Code corre	Sector	Portfolio weight	Portfolio Return	Portfolio Return adj	Benchmark weight	Benchmark Return	AAi	SSi	Cov(aa,alpha)	cov(ss,alpha)	IR_AA	IR_SS	Expected Return Benchmark	24.290	
1	Consumer Discretionary	3.418068715	0.2793	0.046938736	3.640943439	0.014893996	5.410407471	0.054882	-0.027281836	0.002743568	-23.9783	1.951983	Expected Return Portfolio	24.730	
2	Consumer Staples	2.398150527	0.0936	0.032714646	2.70208381	0.018097292	7.377175336	0.128967	0.050481548	0.001924914	-32.6947	0.624717	alpha (adjusted)	0.440	
3	Energy	24.35753737	13.3919	0.285006464	24.34165331	0.291266807	-0.381204479	0.675487	0.05744945	0.019550971	1.689451	-2.7175	AA	0.075	
4	Financials	31.53520841	10.9038	0.281177509	31.23425693	0.26648912	-7.230046241	0.006127	-0.026052405	0.025312245	32.04267	8.254833	SS	1.531	
5	Health Care	1.740643303	0.0744	0.013304973	1.545683536	0.011814757	-4.73335674	-0.02057	-0.030400224	0.001397156	20.97765	0.046227	T	0.451	
6	Industrials	5.098627084	0.6937	0.04817616	5.175177467	0.048899473	1.855699862	-0.24932	-0.101784453	0.004092495	-8.22423	-0.06572	IRp	2.278	
7	Information Technology	1.634430067	0.0319	0.016295202	1.831921227	0.013206978	4.794540563	-0.00134	-0.011594561	0.001311902	-21.2488	0.089953	Stand alone	0.013	
8	Materials	22.77008592	20.1594	0.359494754	22.76162125	0.364530576	-0.202525094	0.872476	0.054172649	0.018276778	0.897566	-2.04349	Contributed	0.178	
9	Telecommunication Services	4.270430266	0.102	0.030070277	4.774444699	0.030007883	12.2276121	0.039157	0.015524033	0.00342773	-54.1913	0.004748		SS	AA
10	Utilities	2.776818329	0.2752	0.026166476	1.992214335	0.018932217	-19.04352846	0.025482	0.019485799	0.002228858	84.39857	0.357997	Component IR	0.038	0.002

Appendix 5: Results for time period 2001-2006

Appendix 5a – Current weights

		Data		Attribution		Risk Attribution		Information Ratio				
Code corr	Sector	Portfolio weight	Benchmark weigl	AAi	SSi	Cov(aa,alp	cov(ss,alp	IR_AA	IR_SS	overall ret	36.13844	
1	Consumer Discretionary	2.253812706	3.640943439	50.10323	0.105737	-0.06544	0.003329	-3379.98	39.41742	overall ret	40.93743	
2	Consumer Staples	5.268791806	2.70208381	-92.695	0.277932	0.121081	0.007782	6253.232	103.6091	alpha	4.798995	
3	Energy	27.26264066	24.34165331	-104.016	0.576976	0.137794	0.040269	7016.92	215.0889	AA	2.1913	
4	Financials	29.90963595	31.23425693	47.36704	-0.65143	-0.06249	0.044179	-3195.39	-242.844	SS	2.607695	
5	Health Care	0	1.545683536	55.86362	0	-0.07292	0	-3768.58	0	T	16.46925	
6	Industrials	0	5.175177467	186.7798	0	-0.24413	0	-12600.2	0	IRp	1.924351	
7	Information Technology	1.242401803	1.831921227	21.29925	0.016274	-0.02781	0.001835	-1436.85	6.066873	Stand alor	0.003835	
8	Materials	25.51600135	22.76162125	-98.2207	2.215014	0.129934	0.037689	6625.993	825.727	Contributi	0.01457	
9	Telecommunication Services	5.56375607	4.774444699	-28.5099	0.077934	0.037235	0.008218	1923.289	29.05256		SS	AA
10	Utilities	2.98295965	1.992214335	-35.7804	-0.01074	0.046737	0.004406	2413.759	-4.00505	Compone	0.005106	4.22E-05

Appendix 5b TEV weights

	Data		Attribution		Risk Attribution		Information Ratio		overall return benchmark	36.13844	
Sector	Portfolio weight	Benchmark weight	AAi	SSi	Cov(aa,alpha)	cov(ss,alpha)	IR_AA	IR_SS	overall return portfolio		
Consumer Discretionary	2.253812706	3.640943439	-0.47953	0.171437	-0.065436174	0.005397558	0.386942991	1.354467368	alpha	0.15	
Consumer Staples	5.268791806	2.70208381	4.343696	0.136192	0.121081271	0.003813525	-3.505004257	0.14841855	alpha(adj)	0.089855	
Energy	27.26264066	24.34165331	-1.71495	0.516177	0.137793961	0.036025595	1.383823552	-3.800258025	AA	0.099617	
Financials	29.90963595	31.23425693	-8.83353	-0.68566	-0.062487354	0.046500237	7.127931329	-0.39781274	SS	1.965387	
Health Care	0	1.545683536	-8.53338	0.005795	-0.072915706	0.002631842	6.88573497	-0.003750181	T	0.196995	
Industrials	0	5.175177467	7.315129	-0.23349	-0.244132588	0.00734475	-5.902705579	-0.038740492	IRp	4.279248	
Information Technology	1.242401803	1.831921227	5.86232	0.021871	-0.027809849	0.00246622	-4.730408391	0.145400213	Stand alone	0.026681	
Materials	25.51600135	22.76162125	0.346834	1.975065	0.12993447	0.033606266	-0.279866751	2.46321495	Contributed	0.524126	
Telecommunication Services	5.56375607	4.774444699	3.85478	0.065382	0.037234786	0.00689458	-3.110488942	0.173749053		SS	AA
Utilities	2.98295965	1.992214335	-2.06175	-0.00738	0.046737183	0.003026975	1.663658282	-0.086046887	Component IR	0.038341	0.004784

Appendix 6: Results for time period 2006-2011

Appendix 6a Current weights

	Data		Attribution		Risk Attribution		Information Ratio				
Sector	Portfolio weight	Benchmark weight	AAi	SSi	Cov(aa,alpha)	cov(ss,alpha)	IR_AA	IR_SS	overall return benchmark	12.63669	
Consumer Discretionary	2.253812706	3.640943439	17.51285	-0.03222	-0.008628045	0.002225616	-9682.41	-19.4147	overall return portfolio	14.71502	
Consumer Staples	5.268791806	2.70208381	-32.4033	0.288665	0.015965094	0.005202875	17914.99	173.9393	alpha	2.078335	
Energy	27.26264066	24.34165331	-36.743	0.932191	0.018168735	0.026921561	20314.28	561.7053	AA	0.405394	
Financials	29.90963595	31.23425693	16.53307	0.652277	-0.00823923	0.02953544	-9140.72	393.0389	SS	1.672941	
Health Care	0	1.545683536	19.49115	0	-0.009614254	0	-10776.2	0	T	17.79701	
Industrials	0	5.175177467	65.13414	0	-0.032189947	0	-36011	0	IRp	0.269438	
Information Technology	1.242401803	1.831921227	7.439106	-0.01803	-0.00366685	0.001226858	-4112.89	-10.8637	Stand alone	0.004754	
Materials	25.51600135	22.76162125	-34.1113	-0.23935	0.017132427	0.025196774	18859.29	-144.223	Contributed	0.005839	
Telecommunication Services	5.56375607	4.774444699	-9.94159	0.02454	0.004909569	0.005494149	5496.456	14.78687		SS	AA
Utilities	2.98295965	1.992214335	-12.5057	0.064867	0.006162502	0.00294564	6914.079	39.08628	Component IR	0.013235	0.00015

Appendix 6b: TEV weights

	Data		Attribution		Risk Attribution		Information Ratio		overall return benchmark	12.6366865	
Sector	Portfolio weight	Benchmark weight	AAi	SSi	Cov(aa,alpha)	cov(ss,alpha)	IR_AA	IR_SS	overall return portfolio		
Consumer Discretionary	2.253812706	3.640943439	8.537971	-0.04238	-0.008628045	0.00292759	-138.6970625	-0.757612543	alpha	0.15	
Consumer Staples	5.268791806	2.70208381	3.300687	0.133717	0.015965094	0.002410098	-53.61878105	0.772717534	alpha(adj)	0.800380937	
Energy	27.26264066	24.34165331	2.146995	0.826477	0.018168735	0.023868572	-34.87736265	9.664120108	AA	0.023955271	
Financials	29.90963595	31.23425693	-3.0872	0.686558	-0.00823923	0.031087739	50.1507814	16.47833964	SS	1.121981622	
Health Care	0	1.545683536	2.382613	-0.03614	-0.009614254	0.001339764	-38.70491525	-0.074303101	T	0.522917108	
Industrials	0	5.175177467	-5.53015	-0.28528	-0.032189947	0.005544328	89.83586271	0.407417757	IRp	1.171995102	
Information Technology	1.242401803	1.831921227	-4.77786	-0.03208	-0.00366685	0.002182892	77.61506647	-0.445617138	Stand alone	0.011307333	
Materials	25.51600135	22.76162125	-0.18878	-0.21365	0.017132427	0.022491906	3.066731119	-13.584625	Contributed	0.109571563	
Telecommunication Services	5.56375607	4.774444699	11.38213	0.017073	0.004909569	0.003822335	-184.8997351	-0.620727077		SS	AA
Utilities	2.98295965	1.992214335	-14.1424	0.067686	0.006162502	0.003073688	229.7402679	1.220302319	Component IR	0.031195243	0.001538

Appendix 7: Sensitivity Analysis Weights

Sector	Benchmark weight	Portfolio weight	1	2	3	4	5	6	7	8	9	10
Consumer Discretionary	3.640943439	3.418068715	3.501623	2.583796485	2.708605819	3.828944423	4.478768	3.463751	3.115011	3.140368	3.405755	3.515518
Consumer Staples	2.70208381	2.398150527	2.207443	2.061243385	3.101275229	3.106744281	1.998392	1.191341	3.075715	2.159687	2.815881	3.744879
Energy	24.34165331	24.35753737	24.46927	24.23877917	24.12858057	24.36787155	24.05479	24.70359	23.93769	24.01361	24.61968	24.27287
Financials	31.23425693	31.53520841	31.35219	30.90092126	30.55722213	31.92506259	30.62475	31.43199	31.9272	31.45947	31.41035	31.50527
Health Care	1.545683536	1.740643303	2.754714	1.652683702	2.089568862	1.51243093	2.152281	2.059339	0.368157	2.034461	0.857213	0.635065
Industrials	5.175177467	5.098627084	4.737212	5.518758996	4.080326788	5.069449638	5.42233	5.088755	4.34925	4.674899	6.083613	4.760452
Information Technology	1.831921227	1.634430067	0.92958	3.120727721	2.230625791	1.618270116	2.774288	2.574005	2.702157	2.992221	1.190569	2.596381
Materials	22.76162125	22.77008592	22.59373	22.55816652	22.79059175	22.83829282	22.52298	22.53568	22.93903	22.79752	22.66316	23.01346
Telecommunication Services	4.774444699	4.270430266	5.058976	5.129213163	6.65303069	4.360078412	5.280234	4.14002	4.999276	4.152091	4.718299	4.143819
Utilities	1.992214335	2.776818329	2.395259	2.235709609	1.660172372	1.372855246	0.691188	2.811528	2.586506	2.575674	2.235482	1.812283

Sector	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Consumer Discretionary	4.212144	3.719949	4.367372	3.026308	3.71136	2.829667	4.054662	3.639135	3.699819	3.699819	4.434687	3.047472	4.12267	4.36921
Consumer Staples	3.584249	3.595939	3.138374	2.745862	1.916517	1.953226	2.260722	2.658208	1.873749	1.873749	2.166741	1.844356	2.809595	1.532066
Energy	24.30401	23.82406	23.98205	24.54758	24.53439	24.30113	24.60781	24.23889	24.30887	24.30887	24.2159	25.28454	24.84131	24.56846
Financials	30.88059	31.38757	31.0126	30.91584	31.40939	30.90891	32.01395	31.46611	31.43308	31.43308	31.44051	31.64987	32.67993	31.11749
Health Care	1.7499	0.932329	2.188094	0.422739	1.770643	1.21936	1.699215	0.819581	3.079876	3.079876	0.587611	0.999301	0.821116	1.281262
Industrials	5.876296	5.351094	5.139672	5.434	5.223599	5.077951	5.62239	5.986749	4.493883	4.493883	6.066099	5.6092	5.485411	4.77929
Information Technology	2.765915	2.953367	1.480447	0.619696	2.291898	1.710841	0.221585	2.188198	1.531398	1.531398	1.768946	1.839598	-2.514	2.974899
Materials	22.85208	22.55642	22.7854	22.71018	22.97844	22.80066	22.9308	22.89726	22.80366	22.80366	22.73013	22.99608	23.30548	22.74961
Telecommunication Services	2.825087	4.55187	3.890355	6.644332	6.043934	6.883678	4.832107	4.799926	5.275668	5.275668	5.334055	6.724367	5.238002	4.170761
Utilities	0.949733	1.127397	2.015641	2.933465	0.119829	2.314585	1.756754	1.30594	1.499999	1.499999	1.255322	0.005212	3.210482	2.456958

25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	std
4.713202	3.640873	3.719978	3.728111	3.519682	4.726961	3.624126	3.850764	4.624577	4.919096	3.142348	3.066259	3.848664	3.043031	3.78684	3.821882	2.747002	4.034791	3.644543	4.063894	4.142298	4.028942	3.299195	3.765781	4.214805	4.082077	0.550053
3.270301	2.401626	3.14266	1.928229	1.697539	2.594089	3.59953	1.821197	3.880717	2.69033	2.663545	2.628894	3.283935	3.035299	1.952777	6.216621	1.969664	2.445432	3.574821	3.003772	2.934247	2.440416	2.850822	3.295389	3.04879	2.54141	0.811711
24.12265	25.112	23.78648	24.10124	24.44054	24.32261	24.22341	24.22361	24.27365	24.31344	24.18051	23.81265	24.7431	24.1334	24.21536	25.3036	24.48512	24.65659	24.33082	24.58809	24.27163	24.09776	24.52558	24.41834	24.63474	24.46147	0.324298
31.90695	31.39884	30.78967	31.03416	31.34748	30.78998	31.02866	31.62209	31.51602	31.40114	31.41775	31.60291	31.39333	30.96982	31.47495	31.37419	31.60853	32.05696	31.51642	30.83361	31.7505	31.52788	31.49517	31.16704	31.49616	31.34496	0.394498
0.305343	1.509693	1.138504	1.779674	3.130917	0.807302	-0.29484	2.641362	-0.13149	1.454611	1.185364	2.845894	1.464009	1.26367	1.041269	1.611501	2.315024	1.50726	1.846716	2.167699	1.156776	1.220604	2.350093	3.179298	0.509329	0.190049	0.854946
5.228471	5.457778	5.421033	5.936057	5.26561	4.764625	4.751425	4.925439	4.90366	5.572124	5.503259	4.603822	5.260525	4.999502	5.30016	3.640119	3.864076	4.57788	4.050639	5.179005	5.656972	4.126553	4.708479	6.192801	5.098215	4.89468	0.582629
1.909141	2.065014	1.16816	2.199137	1.336779	2.186711	3.703289	1.168928	0.734153	1.205511	1.200261	2.392304	0.42652	2.194457	2.074284	1.068185	2.778737	2.087237	1.486344	1.285824	1.826181	2.445314	1.948007	1.965766	1.345273	2.793043	0.972107
22.70135	22.37495	23.10315	23.11425	22.85259	22.52539	22.41102	22.73036	22.3659	22.78884	23.18964	22.97506	22.86724	22.58467	23.25549	22.34378	22.66763	22.48569	22.75492	22.73119	22.63574	22.59905	22.95569	22.41681	23.15419	22.72939	0.230686
3.874192	4.071718	5.579787	4.696267	3.814329	5.436009	5.050325	4.709376	4.77836	3.884132	4.883469	4.055789	3.942229	4.712989	5.039626	4.79697	6.288557	5.189998	6.037778	3.064778	3.707526	4.98474	3.78542	2.090191	5.292413	5.416951	0.975122
1.968392	1.967504	2.150573	1.482881	2.594534	1.846325	1.903061	2.306882	3.054455	1.770775	2.633847	2.016419	2.770445	3.063164	1.859247	-0.17686	1.27566	0.958161	0.757008	3.08214	1.918122	2.528738	2.081548	1.50858	1.206082	1.545974	0.797691

Appendix 8: Current Benchmark and Portfolio Weights

Sector	Name	% Portfolio Net asset	% Benchmark Net asset
Consumer Discretionary	ASTRAL MEDIA INC. (CL A)	0.00	0.1488436
Consumer Discretionary	COGECO CABLE INC.	0.00	0.080146554
Consumer Discretionary	CORUS ENTERTAINMENT INC. (CL B)	0.00	0.114495077
Consumer Discretionary	CANADIAN TIRE CORP. LTD.	0.00	0.34348523
Consumer Discretionary	DOREL INDUSTRIES INC. (CL B)	0.56	0.057247538
Consumer Discretionary	FORZANI GROUP LTD. (CL A)	0.00	0.057247538
Consumer Discretionary	GILDAN ACTIVEWEAR INC.	0.00	0.228990153
Consumer Discretionary	LINAMAR CORP.	0.00	0.068697046
Consumer Discretionary	MAGNA INTERNATIONAL INC.	0.00	0.847263568
Consumer Discretionary	QUEBECOR INC. (CL B)	0.00	0.103045569
Consumer Discretionary	REITMANS (CANADA) LTD. (CL A)	1.69	0.057247538
Consumer Discretionary	SHAW COMMUNICATIONS INC. (CL B)	0.00	0.572475384
Consumer Discretionary	THOMSON REUTERS CORPORATION	0.00	0.927410121
Consumer Discretionary	TRANSAT A.T. INC. (CL B)	0.00	0.034348523
Consumer Staples	ALIMENTATION COUCHE TARD INC. (CL	0.00	0.297687199
Consumer Staples	COTT CORP.	0.00	0.057247538
Consumer Staples	LOBLAW COS. LTD.	0.00	0.286237692
Consumer Staples	MAPLE LEAF FOODS INC.	0.00	0.057247538
Consumer Staples	METRO INC. (CL A)	2.83	0.366384245
Consumer Staples	SAPUTO INC.	2.44	0.446530799
Consumer Staples	SHOPPERS DRUG MART CORP.	0.00	0.652621937
Consumer Staples	VITERRA INC.	0.00	0.297687199
Consumer Staples	GEORGE WESTON LTD.	0.00	0.240439661
Energy	ADVANTAGE OIL & GAS LTD.	0.00	0.080146554
Energy	ALTAGAS LTD.	0.00	0.160293107
Energy	ARC RESOURCES LTD.	0.00	0.538126861
Energy	BIRCHCLIFF ENERGY LTD.	0.00	0.125944584
Energy	BONTERRA ENERGY CORP.	0.00	0.057247538
Energy	CAMECO CORP.	2.33	0.755667506
Energy	CALFRAC WELL SERVICES LTD.	0.00	0.091596061
Energy	CANADIAN NATURAL RESOURCES LTD.	4.56	3.171513625
Energy	CANADIAN OIL SANDS LTD.	0.00	0.950309137
Energy	DAYLIGHT ENERGY LTD.	0.00	0.1488436
Energy	DENISON MINES CORP.	0.00	0.045798031
Energy	ENCANA CORP.	5.72	1.545683536
Energy	ENBRIDGE INC.	4.93	1.82047172
Energy	ENERPLUS CORP.	0.00	0.400732768
Energy	ENSIGN ENERGY SERVICES INC.	0.00	0.19464163
Energy	FLINT ENERGY SERVICES LTD.	0.00	0.045798031
Energy	FREEHOLD ROYALTIES LTD.	0.00	0.068697046
Energy	HUSKY ENERGY INC.	0.83	0.526677353
Energy	IVANHOE ENERGY INC.	0.00	0.034348523
Energy	IMPERIAL OIL LTD.	0.00	0.801465537
Energy	INTER PIPELINE FUND	0.00	0.297687199
Energy	MULLEN GROUP LTD.	0.00	0.137394092
Energy	NAL ENERGY CORP.	0.00	0.125944584
Energy	NIKO RESOURCES LTD.	0.00	0.217540646
Energy	NEXEN INC.	0.00	0.881612091
Energy	PETROBANK ENERGY & RESOURCES LTD.	0.00	0.114495077
Energy	PRECISION DRILLING CORP.	0.00	0.34348523
Energy	PEYTO EXPLORATION & DEVELOPMENT CO	0.00	0.228990153
Energy	PARAMOUNT RESOURCES LTD.	0.00	0.068697046
Energy	PEMBINA PIPELINE CORP.	0.00	0.320586215
Energy	PASON SYSTEMS INC.	0.00	0.068697046
Energy	PROVIDENT ENERGY LTD.	0.00	0.171742615
Energy	PENN WEST PETROLEUM LTD.	0.00	0.744217999
Energy	BLACKPEARL RESOURCES INC.	0.00	0.125944584
Energy	SHAWCOR LTD. (CL A)	0.00	0.137394092
Energy	SUNCOR ENERGY INC.	5.67	4.316464392
Energy	TRICAN WELL SERVICE LTD.	0.00	0.274788184
Energy	TRINIDAD DRILLING LTD.	0.00	0.091596061
Energy	TRANSGLOBE ENERGY CORP.	0.00	0.057247538
Energy	TALISMAN ENERGY INC.	0.00	1.339592398
Energy	TRANSCANADA CORP.	3.22	2.106709411
Energy	URANIUM ONE INC.	0.00	0.114495077
Energy	VERMILION ENERGY INC.	0.00	0.320586215
Energy	VERESEN INC.	0.00	0.171742615

Financials	A.G.F. MANAGEMENT LTD. (CL B)	0.00	0.103045569
Financials	BROOKFIELD ASSET MANAGEMENT INC. (	0.84	1.190748798
Financials	BOARDWALK REAL ESTATE INVESTMENT T	0.00	0.1488436
Financials	BANK OF MONTREAL	0.00	2.862376918
Financials	BANK OF NOVA SCOTIA	4.87	4.385161438
Financials	BROOKFIELD PROPERTIES CORP.	0.00	0.320586215
Financials	CANADIAN APARTMENT PROPERTIES REAL	0.00	0.114495077
Financials	CI FINANCIAL CORP.	0.00	0.251889169
Financials	CANADIAN IMPERIAL BANK OF COMMERCE	0.00	2.16395695
Financials	COMINAR REAL ESTATE INVESTMENT TRU	3.05	0.091596061
Financials	CANADIAN WESTERN BANK	0.00	0.171742615
Financials	CALLOWAY REAL ESTATE INVESTMENT TR	0.00	0.160293107
Financials	DUNDEE REAL ESTATE INVESTMENT TRUS	0.00	0.125944584
Financials	DUNDEE CORP.	0.00	0.125944584
Financials	EXTENDICARE REAL ESTATE INVESTMENT	0.00	0.057247538
Financials	FIRST CAPITAL REALTY INC.	0.00	0.068697046
Financials	FAIRFAX FINANCIAL HOLDINGS LTD.	0.00	0.549576368
Financials	FIRSTSERVICE CORP.	0.00	0.068697046
Financials	GREAT-WEST LIFECO INC.	2.00	0.457980307
Financials	HOME CAPITAL GROUP INC.	0.00	0.125944584
Financials	H&R REAL ESTATE INVESTMENT TRUST	0.00	0.263338676
Financials	INDUSTRIAL ALLIANCE INSURANCE & FI	0.00	0.240439661
Financials	IGM FINANCIAL INC.	1.59	0.377833753
Financials	LAURENTIAN BANK OF CANADA	0.00	0.080146554
Financials	MANULIFE FINANCIAL CORP.	1.79	2.026562858
Financials	NATIONAL BANK OF CANADA	0.00	0.904511106
Financials	ONEX CORP. (CANADA)	1.86	0.251889169
Financials	POWER CORP. OF CANADA	0.00	0.64117243
Financials	POWER FINANCIAL CORP.	0.00	0.480879322
Financials	CANADIAN REAL ESTATE INVESTMENT TR	0.00	0.171742615
Financials	RIOCAN REAL ESTATE INVESTMENT TRUS	0.00	0.503778338
Financials	ROYAL BANK OF CANADA	7.51	5.518662698
Financials	SUN LIFE FINANCIAL INC.	0.00	1.144950767
Financials	TORONTO-DOMINION BANK	6.39	5.083581406
Health Care	CML HEALTHCARE INC.	0.00	0.057247538
Health Care	NORDION INC.	0.00	0.045798031
Health Care	SXC HEALTH SOLUTIONS CORP.	0.00	0.274788184
Health Care	VALEANT PHARMACEUTICALS INTERNATIO	0.00	1.167849782
Industrials	AECON GROUP INC.	0.00	0.034348523
Industrials	BOMBARDIER INC. (CL B)	0.00	0.629722922
Industrials	CAE INC.	0.00	0.240439661
Industrials	CANADIAN NATIONAL RAILWAY CO.	0.00	2.438745134
Industrials	FINNING INTERNATIONAL INC.	0.00	0.354934738
Industrials	RUSSEL METALS INC.	0.00	0.103045569
Industrials	SNC-LAVALIN GROUP INC.	0.00	0.606823907
Industrials	SUPERIOR PLUS CORP.	0.00	0.091596061
Industrials	STANTEC INC.	0.00	0.091596061
Industrials	TRANSCONTINENTAL INC. (CL A)	0.00	0.080146554
Industrials	TRANSFORCE INC.	0.00	0.080146554
Industrials	TOROMONT INDUSTRIES LTD.	0.00	0.091596061
Industrials	WESTJET AIRLINES LTD.	0.00	0.1488436
Industrials	WESTPORT INNOVATIONS INC.	0.00	0.080146554
Industrials	WESTSHORE TERMINALS INVESTMENT COR	0.00	0.103045569

Information Technology	CELESTICA INC.	0.00	0.125944584
Information Technology	CGI GROUP INC.	0.00	0.354934738
Information Technology	MACDONALD DETTWILER & ASSOCIATES L	0.00	0.160293107
Information Technology	OPEN TEXT CORP.	0.00	0.274788184
Information Technology	RESEARCH IN MOTION LTD.	1.24	0.83581406
Information Technology	WI-LAN INC.	0.00	0.080146554
Materials	BARRICK GOLD CORP.	4.13	3.411953286
Materials	AGNICO-EAGLE MINES LTD.	0.00	0.675520953
Materials	AGRIUM INC.	0.89	0.98465766
Materials	AURIZON MINES LTD.	0.00	0.068697046
Materials	ALACER GOLD	0.00	0.1488436
Materials	CCL INDUSTRIES INC. (CL B)	0.00	0.057247538
Materials	CANFOR CORP.	0.00	0.057247538
Materials	DUNDEE PRECIOUS METALS INC.	0.00	0.057247538
Materials	ENDEAVOUR SILVER CORP.	0.00	0.057247538
Materials	EUROPEAN GOLDFIELDS LTD.	0.00	0.125944584
Materials	ELDORADO GOLD CORP.	0.00	0.675520953
Materials	FIRST QUANTUM MINERALS LTD.	5.53	0.858713075
Materials	FIRST MAJESTIC SILVER CORP.	0.00	0.160293107
Materials	GOLDCORP INC.	2.20	2.736432333
Materials	GREAT BASIN GOLD LTD. (CL A)	0.00	0.068697046
Materials	GABRIEL RESOURCES LTD.	0.00	0.125944584
Materials	GOLDEN STAR RESOURCES LTD.	0.00	0.045798031
Materials	GUYANA GOLDFIELDS INC.	0.00	0.045798031
Materials	HUDBAY MINERALS INC.	0.00	0.171742615
Materials	HARRY WINSTON DIAMOND CORP.	0.00	0.091596061
Materials	IAMGOLD CORP.	0.00	0.538126861
Materials	INMET MINING CORP.	1.36	0.251889169
Materials	IVANHOE MINES LTD.	0.00	0.561025876
Materials	JAGUAR MINING INC.	0.00	0.034348523
Materials	KINROSS GOLD CORP.	0.00	1.32814289
Materials	KIRKLAND LAKE GOLD INC.	0.00	0.080146554
Materials	LABRADOR IRON ORE ROYALTY CORP.	0.00	0.171742615
Materials	LUNDIN MINING CORP.	0.00	0.274788184
Materials	MAJOR DRILLING GROUP INTERNATIONAL	0.00	0.080146554
Materials	MINEFINDERS CORP. LTD.	0.00	0.080146554
Materials	MERCATOR MINERALS LTD.	0.00	0.045798031
Materials	METHANEX CORP.	0.00	0.19464163
Materials	NORTHERN DYNASTY MINERALS LTD.	0.00	0.057247538
Materials	NEO MATERIAL TECHNOLOGIES INC.	0.00	0.080146554
Materials	NOVAGOLD RESOURCES INC.	0.00	0.125944584
Materials	NEW GOLD INC.	0.00	0.309136707
Materials	NORTHGATE MINERALS CORP.	0.00	0.068697046
Materials	NEVSUN RESOURCES LTD.	0.00	0.080146554
Materials	OSISKO MINING CORP. SH	0.00	0.400732768
Materials	PAN AMERICAN SILVER CORP.	0.00	0.228990153
Materials	POTASH CORP. OF SASKATCHEWAN INC.	3.47	3.526448363
Materials	NORTH AMERICAN PALLADIUM LTD.	0.00	0.034348523
Materials	ROMARCO MINERALS INC.	0.00	0.057247538
Materials	RUBICON MINERALS CORP.	0.00	0.045798031
Materials	SHERRITT INTERNATIONAL CORP.	2.41	0.137394092
Materials	SAN GOLD CORP.	0.00	0.068697046
Materials	SEMAFO INC.	0.00	0.171742615
Materials	SILVER STANDARD RESOURCES INC.	0.00	0.160293107
Materials	SILVERCORP METALS INC.	0.00	0.125944584
Materials	TECK RESOURCES LTD.	2.57	1.717426151
Materials	THOMPSON CREEK METALS CO. INC.	0.00	0.103045569
Materials	TASEKO MINES LTD.	0.00	0.057247538
Materials	SINO-FOREST CORP.	0.00	0.137394092
Materials	WEST FRASER TIMBER CO.	0.00	0.103045569
Materials	YAMANA GOLD INC.	2.95	0.698419968
Telecommunication Services	BCE INC.	1.49	2.118158919
Telecommunication Services	MANITOBA TELECOM SERVICES INC.	0.00	0.1488436
Telecommunication Services	ROGERS COMMUNICATIONS INC. (CL B)	1.50	1.225097321
Telecommunication Services	TELUS CORP.	2.58	1.282344859
Utilities	ATCO LTD. (CL I)	0.00	0.183192123
Utilities	BROOKFIELD RENEWABLE POWER FUND	0.00	0.103045569
Utilities	CAPITAL POWER INCOME L.P.	0.00	0.057247538
Utilities	CANADIAN UTILITIES LTD. (CL A)	0.00	0.251889169
Utilities	EMERA INC.	2.98	0.286237692
Utilities	EMPIRE CO. LTD. (CL A)	0.00	0.114495077
Utilities	FORTIS INC. (CANADA)	0.00	0.412182276
Utilities	JUST ENERGY GROUP INC.	0.00	0.137394092
Utilities	NORTHLAND POWER INC.	0.00	0.091596061
Utilities	TRANSALTA CORP.	0.00	0.354934738